Foundational Research Artifacts of Cloud Logistics

Development of Selected Artifacts for Virtualizing, Categorizing and Encapsulating Resources and Services of Logistics within Reusable Modules

Von der Wirtschaftswissenschaftlichen Fakultät
der Universität Leipzig
genehmigte

DISSERTATION

zur Erlangung des akademischen Grades
Doktor-Ingenieur
Dr.-Ing.
vorgelegt

von Dipl.-Ing. Michael Glöckner
geboren am 02. Dezember 1986 in Wurzen

Gutachter: Prof. Dr. André Ludwig (kooptiert von der Kühne Logistics University)
Prof. Dr.-Ing. habil. Bogdan Franczyk (Universität Leipzig)

Tag der Verleihung: 23. Oktober 2019

Man reist ja nicht, um anzukommen,
sondern um zu reisen.

Johann Wolfgang von Goethe

Danksagung

"... und jedem Anfang wohnt ein Zauber inne" aus dem Gedicht 'Stufen' von Herman Hesse beschreibt jedes Gefüge als einen lediglich temporären Teilabschnitt des Lebens und erinnert somit an den beständigen Wandel von Kontext und Bedingungen. Im Zusammenhang mit dem Goethe-Zitat des Epigraphs ergibt sich das Bild fortwährend wechselnder Etappen, welchen nicht nur eine fachliche sondern stets auch eine persönliche Weiterentwicklung inhärent ist. Dabei basiert die Essenz der Weiterentwicklung nicht auf dem erreichten Ziel oder Abschluss, sondern manifestiert sich viel mehr in den Teilschritten und -erfolgen, und Erfahrungen, welche während der jeweiligen Etappe prägen. Jeder Anfang einer Etappe verheist dabei stets sowohl neue Erkenntnisse und neue Horizonte, als auch neue Herausforderungen und ganz eigene Prüfungen. Nach dem Diplom im Fachbereich Verkehrsingenieurwesen der Technischen Universität Dresden, stellte die Promotion in dem völlig neuen Fachgebiet der Wirtschaftsinformatik den Anfang einer ganz besonderen Etappe dar. Entsprechend besonders waren auch die zu erwartenden Erkenntnisse, die neuen Horizonte, sowie die Herausforderungen - der innewohnende Zauber. Die Dissertation ist das Ergebnis einer längeren Reise, auf der ich von vielen Menschen und ihrem Vertrauen in mich profitiert habe und denen ich nun Dank schulde.

Prof. Dr. André Ludwig, kooptierter Professor an der Universität Leipzig und Lehrstuhlinhaber an der Kühne Logistics University in Hamburg, danke ich für das Erstgutachten und seine Rolle als Doktorvater. Ich bedanke mich für die konstruktiven Diskussionen sowie die fortwährend kritische und ausdauernde Betreuung meiner Arbeit. Seine Betreuung war stets geprägt von großem Vertrauen und großer Freiheit bei der Erstellung. Außerdem danke ich ihm für die Möglichkeit als Gastforscher an der Kühne Logistics University tätig gewesen zu sein. Besonders hervorheben möchte ich noch sein Vertrauen zu Beginn meiner Einstellung als Wissenschaftlicher Mitarbeiter an der Professur Wirtschaftsinformatik, insb. Informationssysteme in der Logistik der Universität Leipzig in seiner Rolle als damals noch Juniorprofessor. Somit hat er den Anfang der vorliegenden Dissertation als Reise in ein neues Fachgebiet überhaupt erst ermöglicht.

Prof. Dr.-Ing. habil. Bogdan Franczyk danke ich für die Übernahme des Zweitgutachtens. Weiterhin danke ich ihm für die konstruktiven fachlichen Diskussionen sowie die kommissarische Leitung der Professur für Informationssysteme in der Logistik, und die Anstellung im neuen BMWi-Forschungsprojekt 'SMile' sowie die beständige Forderung und Förderung meiner Person durch ein mannigfaltiges Aufgabenspektrum.

Prof. Dr. Dubravko Radić danke ich für die Übernahme des Vorsitzes der Promotionskommission.

Dem Bundesministerium für Bildung und Forschung (BMBF) danke ich für die Förderung des Projekts 'Logistik Service Engineering und Management' (LSEM). Aus der Arbeit im Projekt LSEM, der spannenden Aufgabenstellung, der finanziellen Förderung von u. a. Konferenzreisen in verschiedenste Teile der Erde (bspw. Hawaii, Alaska, Osaka, and Shanghai), resultierte nicht nur die thematische Grundlage der Arbeit und die fachliche Weiterentwicklung durch den Austausch mit internationalen Kollegen aus vielen Länder dieser Erde. Aus den Workshops, Konferenzen, und den persönlichen Begegnungen resultierte vor allem auch eine unschätzbare und unbezahlbare, kulturelle und persönliche Entwicklung und Horizonterweiterung.

Ein herzlicher und freundschaftlicher Dank geht an meine Kollegen am Institut für Wirtschaftsinformatik. Mit einer exzellenten Mischung aus freundschaftlicher und herausfordernder Arbeitsatmosphäre haben sie nicht nur zu meiner fachlichen Weiterentwicklung durch Diskussionen und konstruktive Anmerkungen beigetragen, sondern vor allem auch zu meiner persönlichen Weiterentwicklung. Nicht nur in geselligen Runden haben sie mir dabei viel Freude bereitet. Besonders erwähnenswert sind hierbei Dr. Stefan Mutke, Dr.-Ing.(!) Martin Roth, Dr. Christoph Augenstein, Dr. Richard Müller, Norman Spangenberg, Benjamin Gaunitz, Robert Wehlitz, Theo Zschörnig, Ingolf Römer, André Müller, Matthias Wittwer, Carina Cundius, und Mitarbeiter des FSZ IT, wie Dr. Wilfried Röder, Andreas Barton und Konstantin Schelzel, Marc Weber, Ben Merz, und Steven Zeuke, um nur einige zu nennen. Außerdem besonders erwähnenswert sind ehemalige Kollegen wie Björn Schwarzbach (einer meiner Lieblings-Paper-Coautoren und Mitreisenden), Hendrik Kerkhoff (Lieblingsknuddel- und Sparingspartner), Dr. Christopher Klinkmüller mit seinen besonderen Überraschungen, Robert Kunkel und Marcus Grieger. Weiterhin möchte ich besonderen Dank an meine studentische Hilfskraft Tim Niehoff richten für die Mithilfe bei der Entwicklung des Prototypen. Außerdem danke ich Viola Keller für die Übernahme des Lektorats und die schöne Zeit während der Erstellung der Dissertation. Speziellen Dank schulde ich Sebastian Hupfer für seine humorvolle Gesellschaft während der Mittagspausen, tiefsinnigen Diskussionen und alle besonderen Dinge, die er in mein Leben gebracht hat.

Zu guter Letzt danke ich meinen Eltern Annelie und Werner vom Grunde meines Herzens für ihre bedingungslose und beständige Liebe und Unterstützung bei meinem bisherigen Lebens- und Ausbildungsweg. Besonders hervorheben möchte ich die tatkräftige und finanzielle Unterstützung während des Diplomstudiums in Dresden als Grundstein dieser Promotion sowie den fortwährenden Rückhalt und die Hilfestellung bei jedweden anderweitigen Vorhaben und Projekten, die mir so in den Sinn kommen, wenn der Tag lang ist.

Ein herzlicher Dank an alle für die Unterstützung, die Anfänge, die Etappen, die Erkenntnisse, die neuen Horizonte, die Herausforderungen und den Zauber.

Leipzig, 22. Januar 2019 Michael Glöckner

Acknowledgment

"...a magic dwells in each beginning" from the poem 'Stufen' by Herman Hesse describes every structure and order as a merely temporary part of life and thus reminds of the constant change of context and conditions. In connection with the Goethe quotation of the epigraph, the picture of continuously changing stages arises, which inherently contain not only a professional but also a personal development. The essence of the further development is not based on the achieved goal or degree, but manifests itself much more in the partial steps and successes, and experiences that characterize the respective stage. Each beginning of a stage always promises new insights and new horizons, as well as new challenges and very own exams. After graduating in the field of Transport Engineering at the Dresden University of Technology, the doctorate in the completely new field of information systems represented the beginning of an extraordinary stage. The expected findings, the new horizons and the challenges - the inherent magic - were correspondingly exceptional. The dissertation is the result of a long journey on which I benefited from many people and their trust in me and to whom I now owe thanks.

I would like to thank Prof. Dr. André Ludwig, co-opted professor at Leipzig University and chair holder at Kühne Logistics University in Hamburg, for the first review of the thesis and his role as a doctoral supervisor. I would like to thank him for the constructive discussions and the continuous critical and persevering supervision of my thesis. His support has always been characterized by great trust and great freedom during in the thesis' creation. I would also like to thank him for the opportunity to work as a visiting researcher at Kühne Logistics University. I would particularly like to emphasize his trust at the beginning of my employment as a research assistant at the Chair of Information Systems, especially Logistics Information Systems at Leipzig University in his role as junior professor at that time. Thus, he made the beginning of this dissertation as a journey into a new field possible in the first place.

I would like to thank Prof. Dr.-Ing. habil. Bogdan Franczyk for the second review. Furthermore, I would like to thank him for the constructive discussions as well as the temporary management of the professorship for logistics information systems, the employment in the new research project 'SMile' and the constant demand, development and support of my person through a diverse range of tasks.

I would like to thank Prof. Dr. Dubravko Radić for taking over the chairmanship of the doctoral commission.

I would like to thank the Federal Ministry for Research and Development (BMBF) for funding the project 'Logistics Service Engineering and Management' (LSEM). The work in the project LSEM, the exciting task, the financial support of conference trips to different parts of the world (e.g. Hawaii, Alaska, Osaka, and Shanghai), did not only result in a thematic basis of the thesis and my personal professional development through the exchange with international colleagues from many countries of the world. The workshops, conferences and personal encounters resulted in an invaluable and priceless cultural and personal development and broadening of horizons.

A cordial and friendly 'thank you' is given to my colleagues at the Information Systems Institute. With an excellent mixture of friendly and challenging working atmosphere, they not only contributed to my professional development through discussions and constructive comments, but also to my personal development. They have given me a lot of pleasure not only in social gatherings. Especially worth mentioning here are Dr. Stefan Mutke, Dr.-Ing.(!) Martin Roth, Dr. Christoph Augenstein, Dr. Richard Müller, Norman Spangenberg, Benjamin Gaunitz, Robert Wehlitz, Theo Zschörnig, Ingolf Römer, André Müller, Matthias Wittwer, Carina Cundius, and FSZ IT staff, such as Dr. Wilfried Röder, Andreas Barton, Konstantin Schelzel, Marc Weber, Ben Merz, and Steven Zeuke, to name but a few. Also worth mentioning are former colleagues like Björn Schwarzbach (one of my favourite paper co-authors and fellow travelers), Hendrik Kerkhoff (favourite cuddle and sparring partner), Dr. Christopher Klinkmüller with his very special surprises, Robert Kunkel and Marcus Grieger. Furthermore I would like to express my special thanks to my student assistant Tim Niehoff for his help in developing the prototype. I would also like to thank Viola Keller for the editing and for the wonderful time during the writing of the dissertation. I also owe special thanks to Sebastian Hupfer for his humorous companionship during lunch breaks, deep discussions and for every special aspect he brought to my life.

Last but not least I would like to thank my parents Annelie and Werner from the bottom of my heart for their unconditional and constant love and support during my life and education so far. I would especially like to emphasize the active and financial support during my diploma studies in Dresden as the foundation of this doctorate as well as the continuous support and assistance with any other projects that come to my mind all day long.

Many thanks to everyone for the support, the beginnings, the stages, the insights, the new horizons, the challenges and the magic.

Leipzig, 22. Januar 2019 Michael Glöckner

Bibliographic Description

Author:	Glöckner, Michael
Title:	Foundational Research Artifacts of Cloud Logistics - Development of Selected Artifacts for Virtualizing, Categorizing and Encapsulating Resources and Services of Logistics within Reusable Modules
Institution:	Leipzig University, Dissertation
Extent:	237 Pages, 191 References, 21 Figures, 12 Tables

Abstract

Modern logistics is strongly influenced by ongoing outsourcing. Numerous logistics service providers as stakeholders, as well as fragmented logistics networks and supply chains, result from this outsourcing and specialization on distinct core competencies. These stakeholders have to collaborate in order to enable complex supply chains. The collaboration is difficult with the inherent heterogeneity between stakeholders in terms of differing naming conventions and differing IT systems. An inadequate integration and poor communication as well as incorrect information lead to mistakes and inefficiency. One promising approach to solve these problems is the interdisciplinary paradigm of *Cloud Logistics*. Several parallels can be drawn between services of cloud computing and services of logistics. The paradigm of Cloud Logistics is based on these parallels and focuses on the adoption of the basic principles from cloud computing to logistics. These principles comprise the virtualization of *all* resources and their encapsulation within reusable modules, the so called cloud logistics services. The essential aspect of the cloud logistics paradigm is to bridge the logistics service providers' heterogeneity and differing naming conventions and IT systems with a semantic approach.

The systematic literature review contained in the thesis reveals existing research gaps in the field of cloud logistics. Shortcomings are, next to others, basic aspects such as a definition and a conceptual framework to set the field of cloud logistics in context to both affecting disciplines - cloud computing and logistics. Essential explicit artifacts describing concepts and semantics of cloud logistics services are missing as well.

Following a design oriented information systems research approach, the contribution of the cumulative thesis comprises the development of these mentioned essential artifacts. Especially the reusable generic ontology design patterns that semantically describe the cloud logistics services and their structuring are important contributions. Summarizing, the thesis contains a basic set of artifacts to enable the paradigm of cloud logistics. The development of a first prototype and the elaboration of an application example in the context of systematic engineering and evaluation of logistics process alternatives complement the course of the thesis.

Zusammenfassung

Logistik ist heutzutage durch eine wachsende Arbeitsteilung und von einem Outsourcing-Trend geprägt. Daraus resultieren fragmentierte Logistiknetzwerke und Supply Chains, welche durch eine Vielzahl von Logistikdienstleistern als Stakeholder geprägt sind. Diese Stakeholder müssen miteinander kollaborieren, um innerhalb der Supply Chains zusammen zuwirken. Die Kollaboration geht mit Herausforderungen einher, welche aus der inhärenten Heterogenität zwischen den Stakeholdern sowie abweichenden Namenkonventionen und IT-Systemen der beteiligten Stakeholder resultiert. Unzureichende Integration, mangelhafte Kommunikation sowie Fehlinformation führen zu Fehlern und Ineffizienzen. Ein vielversprechender Ansatz, um diese Probleme zu lösen, ist das interdisziplinäre Paradigma *Cloud Logistics*. Zwischen Diensten des Cloud Computing und Diensten der Logistik können diverse Parallelen gezogen werden. Das Cloud Logistics Paradigma basiert auf diesen Parallelen und überträgt die Grundprinzipien des Cloud Computing auf die Logistik. Zu diesen Grundprinzipien gehören unter anderem Aspekte wie die Ressourcenvirtualisierung und -kapselung in wiederverwendbaren Modulen, den so genannten Cloud Logistics Services. Essentieller Aspekt des Cloud Logistics Paradigmas ist die Überbrückung der Heterogenität der Logistikdienstleister und ihrer abweichenden Namenskonventionen und IT-Systeme mittels eines semantischen Ansatzes.

Die vorliegende Dissertation deckt mit Hilfe einer systematischen Literaturrecherche bestehende Lücken innerhalb des Forschungsfeldes Cloud Logistics auf. Defizite bestehen, neben anderen Aspekten, vorallem in essentiellen Artefakten des Forschungsfeldes, wie bspw. einer angemessenen wissenschaftlichen Definition, und eines konzeptuellen Frameworks, um das Forschungsfeld in den Kontext der beiden tangierenden Disziplinen - Cloud Computing und Logistik - einzuordnen. Weiterhin mangelt es an essentiellen und explizit beschriebenen Artefakten, welche Konzepte und die Semantik des Engineering und Managements der Cloud Logistics Services beschreiben.

Der Methodologie der gestaltungsorinetierten Wirtschaftsinformatik folgend, besteht der Beitrag dieser Dissertation in der Entwicklung der vorgenannten Artefakte. Besonders die wiederverwendbaren generischen Ontology Design Pattern zur semantischen Beschreibung der Cloud Logistics Services und ihrer Strukturierung stellen einen wichtigen Beitrag dar. Zusammenfassend enthält die Dissertation ein notwendiges Grundset an Artefakten für die Umsetzung des Cloud Logistics Paradigmas. Die Entwicklung eines ersten Prototypen, sowie die Erarbeitung eines Anwendungsbeispiels im Kontext systematischer Entwicklung und Evaluation von Prozessvarianten in der Logistik runden die Arbeit ab.

Contents

List of Figures

List of Tables

List of Abbreviations

2PL	2^{nd} Party Logistics Provider
3PL	3^{rd} Party Logistics Provider
4PL	4^{th} Party Logistics Provider
B2B	Business to Business
BPMN	Business Process Model and Notation
CC	Cloud Computing
CL	Cloud Logistics
DSR	Design Science Research
FEDS	Framework for Evaluation in Design Science
IaaS	Infrastructure-as-a-Service
IS	Information Systems
IT	Information Technology
JQ3	Jourqual 3
LI	Logistics Integrator
LLP	Lead Logistics Provider
LNBIP	Lecture Notes in Business Information Processing
LNCS	Lecture Notes in Computer Science
LoSe ODP	Logistics Service Ontology Design Pattern
LoSeMa ODP	Logistics Service Map Ontology Design Pattern
LSP	Logistics Service Provider
ODP	Ontology Design Pattern
OEM	Original Equipment Manufacturer

OWL	Web Ontology Language
PaaS	Platform-as-a-Service
PSS	Product Service Systems
SaaS	Software-as-a-Service
SCaaS	Supply-Chain-as-a-Service
SCM	Supply Chain Management
SOA	Service Oriented Architectures
WSDL	Web Service Description Language
XML	Extensible Markup Language
XSLT	Extensible Stylesheet Language Transformation

1 Introduction

The paradigmatic shift of logistics towards *Cloud Logistics* unlocks enormous potential for the logistics sector. This change is based on the basic principles of cloud computing and their adoption by logistics networks and supply chains. Potential benefits are higher flexibility, easier collaboration and integration as well as higher competitiveness and financial outcomes for Logistics Service Providers. However, challenges result from this paradigmatic change as well.

In this chapter, as displayed in Figure 1.1, the reader is introduced to the topic areas of logistics and cloud principles (section 1.1). Considering their parallels, various potentials arise from a conversion of the logistics industry on the basis of cloud principles. At the same time, challenges emerge that motivate the research conducted in the current thesis. Those research challenges are described in a more detailed way through the objectives and guiding research questions in section 1.2. Further, the methodological research framework and applied methods are outlined in section 1.3. Eventually, this chapter presents the conceptual structure of the contributions as well as the relations between the scientific papers included in this cumulative thesis in section 1.4.

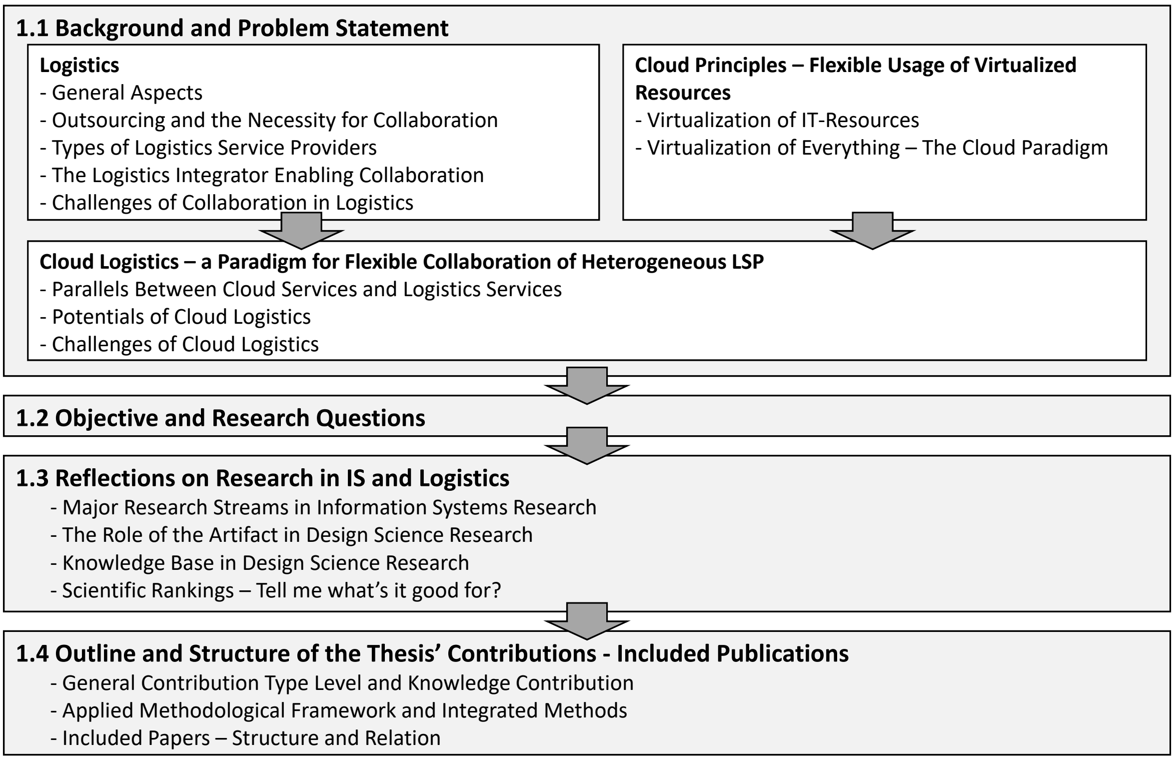

Figure 1.1: The structure of the introductory chapter.

1.1 Background and Problem Statement

Logistics

Essential for society, business and everyday life is the exchange of ideas, thoughts but also physical things. Logistics primarily renders the exchange of physical goods in a professionalized way and thus, holds enormous potential and relevance. This section describes general aspects of logistics and outlines the inherent need for collaboration between the involved stakeholder as well as the resulting concepts and challenges.

General Aspects

Logistics comprises the integrated engineering and management of systems that have the objective of planning, operating and monitoring the realization of spatio-temporal transformation of goods. Next to the flow of goods, logistics also includes the necessary engineering and management of the related flow of information [Gudehus and Kotzab, 2012]. With an annual revenue of over 4.200 bn € worldwide [Clausen and Geiger, 2013], a market volume of 1.000 bn € in Europe [Schwemmer and Pflaum, 2017], and being the third largest industry sector in Germany with almost 3 million employees and a revenue of 222 bn € [Krampe et al., 2012], logistics is an important industrial sector itself in the economic context. Further, logistics is of high economic relevance in today's world as it plays an essential role for the modern globalized society and economy by physically connecting companies and different global areas in order to enable the exchange of goods for production and trade [Gudehus and Kotzab, 2012].

There are different perspectives for structuring logistics, i.e. macro, micro and meta logistics [Lohre et al., 2015; Kersten et al., 2014; Pfohl, 2010]. In the *macro* perspective, logistics is regarded on an overall economic level. Particularly macro economic aspects, such as the global modal split between different means of transport, and aspects of transport politics are in the focus. The *micro* perspective on logistics comprises the context of organisation-internal flows of goods and information. This can be further subdivided into procurement, production logistics, distribution, spare parts logistics, and reverse logistics [Pfohl, 2010]. Finally, the *meta* perspective of logistics includes intra-organizational aspects, such as Supply Chain Management (SCM)[1] and thus rather constitutes a part of macro logistics perspective. Main focus of the meta perspective is set on the optimization of logistics flows across different business locations between multiple companies.

Furthermore, in a planning and management context, strategical, tactical, and operational perspectives on logistics can be distinguished based on the considered time hori-

[1] SCM is *the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole.* [Mentzer et al., 2001]

zon and the extent of functions and responsibilities [Stadtler et al., 2012; Schmidt and Wilhelm, 2000]. The strategic level focuses on a long-term horizon and the foundation of logistics networks, such as locations, basic infrastructure and maximum capacities. Tactical logistics comprises the mid-term horizon and focuses on contracts, process planning, inventory levels and the integration of information and material flows. On the operational level, aspects such as actual operations to assure in-time delivery of goods are planned and managed. Those different perspectives can not be separated completely from each other as they form the basis for the more detailed ones as well as they provide feedback and experience for future planning on less detailed levels.

Outsourcing and the Necessity for Collaboration

Logistics evolved from being just a support function in companies to being a fully developed standalone service-based sector of economy. This is a consequence of the professionalization that comprises specialization or concentration on core competencies, respectively. Hence, business models, which contain outsourcing activities, have emerged in the field of logistics [Langley and Long, 2017; Langley and Long, 2016; Stefansson, 2006; Wilding and Juriado, 2004].

Especially in meta logistics and the context of inter-organizational business connections, it is common that companies use outsourcing to run the material flow. Outsourcing describes the delegation of responsibility to external third parties for the execution of business tasks and operations that have been originally operated internally by a company itself [Raubenheimer, 2010]. The basic decision on whether to outsource or not is made on a strategic level and is based on corporate policy. Goals of outsourcing are an increased flexibility, higher efficiency, innovative capabilities [Langley and Long, 2018; Raubenheimer, 2010; Langley and Long, 2016; Subramanian et al., 2016; Prajogo and Olhager, 2012; Selviaridis and Spring, 2007; Corsten and Felde, 2005]. Outsourcing can lead to a better operational performance [Liu et al., 2015] due to incorporating the knowledge of logistics specialists. Outsourcing is common practice and especially became prevalent in the context of logistics services in general (over 50% of all logistics services are outsourced [Schwemmer and Pflaum, 2017]) and for commodity like services, such as domestic transportation (83 %), and warehousing (66 %), in particular [Langley and Long, 2018]. Functions and services in logistics, especially outsourced ones, are generally provided by LSP [Hingley et al., 2011; Stefansson, 2006]. Particularly LSPs connect different market participants, i.e. suppliers with Original Equipment Manufacturer (OEM), OEM with wholesale and retailers, and them finally with customers in order to form (global) supply chains, see Figure 1.2.

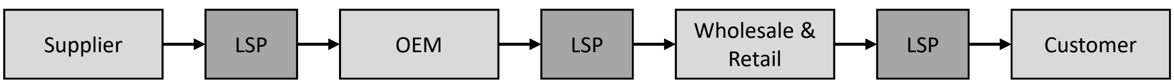

Figure 1.2: The role of the LSP in the supply chain, adapted from Baumgarten [2008].

Outsourcing of different logistics activities to different partners results in fragmented logistics chains. Thus, outsourcing and the inherent specialization of each LSP lead to the need of *collaboration* in networked economies [Handfield et al., 2013] in order to meet complex customer demands by orchestrating services of several specialized LSP. Collaboration between the involved LSP is unavoidable.

Types of Logistics Service Providers

With ongoing outsourcing and specialization, LSP also focus on taking over further tasks and processes of their customers in order to increase revenue by fulfilling more value-adding functions [Lohre et al., 2015]. Hence, different types of LSP and collaborations evolve. Different role schemes with differing namings can be found in logistics environments of specialized LSP. Commonly, basic characteristics of distinction in these role schemes are (1) the ownership of physical assets, (2) the assignment of subcontractors, and (3) the complexity of the provided services (in terms of degree of customization and scope of services) [Hingley et al., 2011; Selviaridis and Spring, 2007; Stefansson, 2006]. With these characteristics, different types of LSP can be described [Lohre et al., 2015; Gudehus and Kotzab, 2012; Arnold et al., 2008], see Figure 1.3 and the following descriptions.

Single LSP focus on the simple original core functions of logistics, e.g. transportation, transshipment, and warehousing. Further, specialized services can also be included, such as customs clearance, or refrigerated logistics. Those services can be directly performed concerning a customer's order by a 2^{nd} Party Logistics Provider (2PL). They are characterized by (1) owning or at least using physical assets, (2) not assigning subcontractors, and (3) offering rather simple and standardized services that are not customizable. Those LSPs focus on specific types of goods, specific tasks, and specific regions.

Compound LSP fulfill more complex functions, which are a combination of the former core functions, as well as complete process performances, such as order taking and processing, or track and trace. They not only take orders, perform tasks with regard to statical given parameters (such as destination address, cooling level, etc.) and just give feedback on the successful fulfillment (as single LSP do), but also return data to customers during execution for information purpose and/or for for replanning and re-adjusting operations towards customer needs on the fly. Compound LSP are also labeled as 3^{rd} Party Logistics Provider (3PL) and they can be characterized by (1) owning or at least using physical assets, (2) assigning subcontractors (i.e. 2PL), and (3) offering rather complex services that have to be customizable concerning customer demand. These LSPs focus on performance-specific aspects of linked basic services within national and global networks.

System LSP possess and/or operate whole logistics systems. The concept of 3PL can also be labeled as system LSP in case of high responsibility for planning and controlling

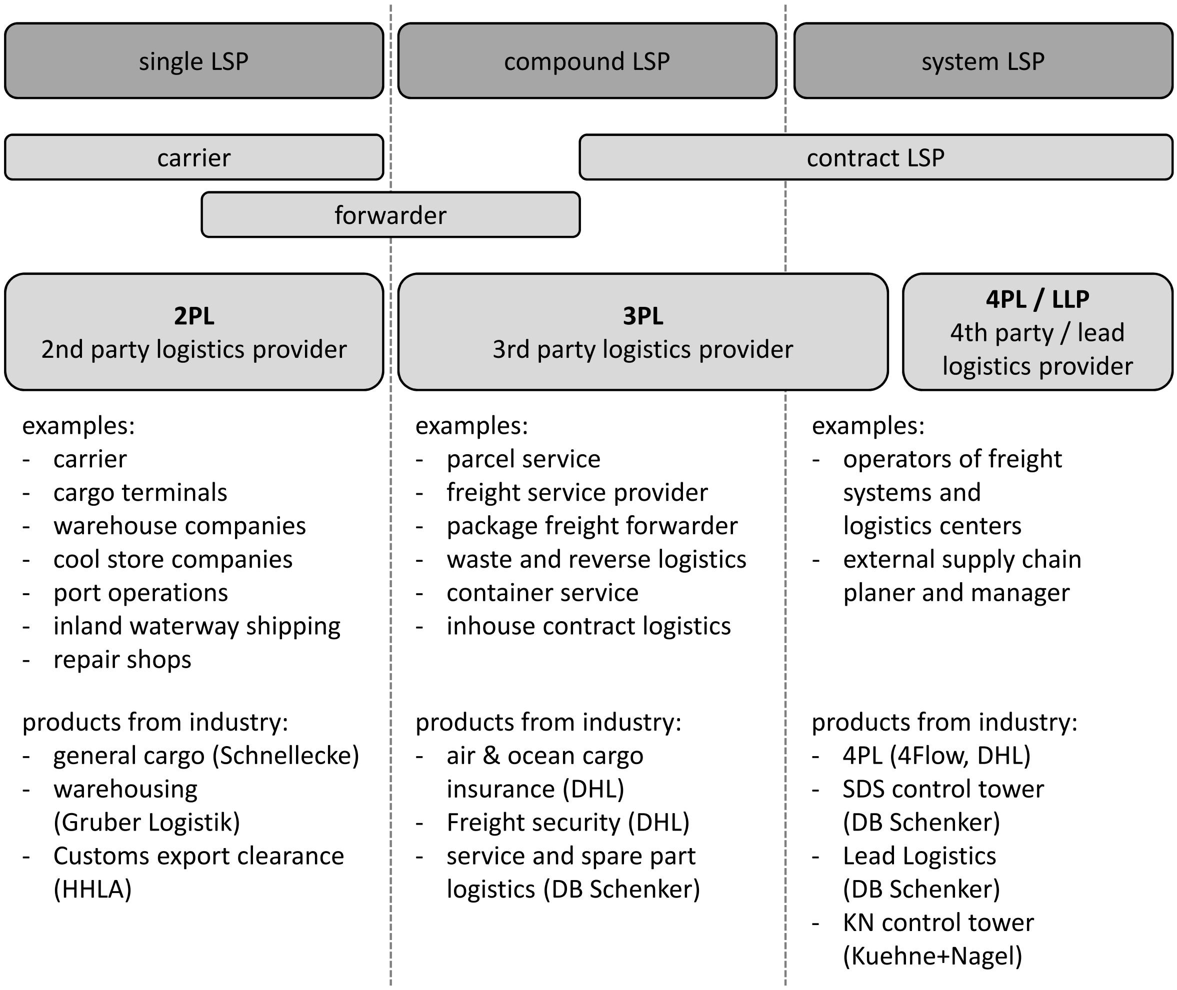

Figure 1.3: Types of LSP, adapted and extended from [Arnold et al., 2008].

of logistics systems. Further, this comprises also the abstract management of logistics networks and the initiation of collaborations of several 3PL. Such a business model is labeled Lead Logistics Provider (LLP) or 4^{th} Party Logistics Provider (4PL). These business models of LSP are characterized by (1) owning or at least using physical assets (in case of the LLP) or not even owning or using physical assets (in case of the 4PL), (2) assigning subcontractors (3PL) and inherently even subsubcontractors (2PL), and (3) offering complex services that are highly customizable up to individualized supply chains and supply networks as well as special services for abstract logistics functions, e.g. Information Technology (IT) integration, administrative services such as network management, or systematic consulting. System LSP focus on customer specific solutions and are able to invoke services from further specialists if needed.

The Logistics Integrator Enabling Collaboration

Successful and trustful collaboration and business partnerships must be based on a common cooperation strategy, complementary resources, and organizational compatibility [Ryu et al., 2009]. Volatile business environments like logistics in particular require sophisticated coordination mechanisms as a success factor [Audy et al., 2012].

Those coordination mechanisms are part of system LSPs' business models, which have a strong focus on the planning of comprehensive supply chains and logistics networks as well as integrating resources and services from several different LSP, such business models are e.g. 4PL without own resources [Pfohl et al., 2013; Hingley et al., 2011; Win, 2008], or LLP combining own and external resources [Singh Bhatti et al., 2010]. As the integration of resources and services from subcontractors is not depending on the ownership and usage of own resources, the concept of the Logistics Integrator (LI) is introduced as an hypernym for both 4PL and LLP. The abstracted role of LI [Jager et al., 2007], or Logistics Orchestrator [Zacharia et al., 2011] respectively, can be found in literature. The LI offers the strategy of 'one-stop shopping' [Pfohl et al., 2013; Peters et al., 2007] in order to be the central point of contact for customers' complex supply chains, each consisting of several specialized compound LSP. The LI responds to volatility, changing demand and sudden disturbances in the supply chain. Such a global and unified platform for outsourced logistics service is desired by shippers [Langley and Long, 2017]. The main challenge for collaboration comprises integration of information flows and information systems [Hingley et al., 2011]. Thus, the planning of supply chains and logistics networks at a higher level as well as the physical and informational integration of LSP is a characteristic task of an LI. Hence, the crucial core competency of an LI as a specialized planning and operating authority is the establishment of a logistics service intermediary that handles complexity [Hingley et al., 2011] and that is concerned with the integration of resources, assets and services from several providers of the network and their flexible provision to customers of the network. As a consequence from the coordination of several different subcontracted LSP, specific challenges arise for the LI that are discussed in the following subsection.

Challenges of Collaboration in Logistics

Especially in the context of meta logistics, tactical logistics planning is an ongoing issue in terms of integrating different LSP within contracts for recurring logistics processes. Tactical logistics planning focuses on the integration and quality of logistics processes within supply chains in order to shape the foundation for the subsequent quantitative elaboration and operations [Pfohl, 2010]. Hence, these are actually the issues that have to be solved by the LI. The planning and integration of those logistics chains on a tactical level is mainly influenced by the following two aspects.

On the one hand, tactical planning in logistics addresses especially the *flexibility* of processes (volume, delivery and preconditions of operation) as well as supply chain design, relationships and inter-organizational information systems [Esmaeilikia et al., 2014; Schütz and Tomasgard, 2011; Stevenson and Spring, 2007]. The term flexibility means the ability to be easily modified by maintaining and analyzing a variety of alternatives in order to choose the best for a specific task under current conditions [Bibhushan et al., 2014]. Customers are demanding a high flexibility, which is also marked as one key success factor in logistics and SCM in order to cope with volatile business environments [Esmaeilikia et al., 2014; Singh and Acharya, 2013; Pfohl et al., 2013; Hartmann and Grahl, 2012; Schütz and Tomasgard, 2011; Stevenson and Spring, 2007; Christopher, 2000]. The ability of flexibly scaling operations and changing between alternatives according to the customer demand is outlined to be a suggested element of successful LSP relationship [Langley and Long, 2016; Pfohl et al., 2013].

On the other hand, the quantity of LSPs in large logistics networks and their differences entail a high *heterogeneity*. The differences descend mainly from differing specializations, as well as from syntactical, structural and semantic differences between service descriptions, enterprise systems, and knowledge [Franke et al., 2016; Metzger et al., 2012; Straube et al., 2008; Fawcett et al., 2007; Rodan and Galunic, 2004].

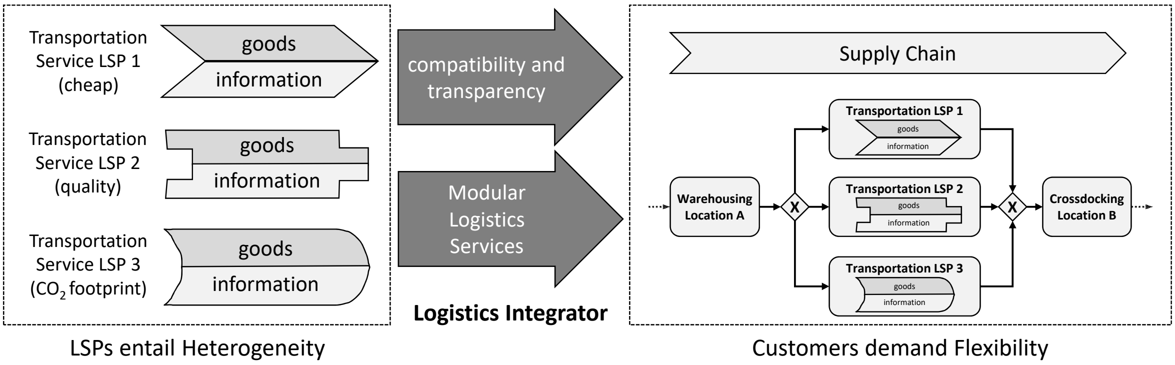

Figure 1.4: The field of tension is created by the heterogeneity of the LSP and the flexibility demanded by customers.

In Figure 1.4, the entailed heterogeneity of systems and descriptions between the three LSPs offering *transportation services* is represented by different task shapes that have to be integrated into the supply chain. The demanded flexibility is represented by several options of a *Transportation Task* between a warehouse in location A and a cross-docking facility in location B. In accordance with the customer preference that can change over time, either LSP 1 (cheapest), LSP 2 (best quality) or LSP 3 (best carbon footprint) shall be chosen to operate the *Transportation Task*. Hence, an LI needs the flexibility to change and direct the flow of goods and information to and between the different LSP in accordance with the current customer preference. The flexibility aspects, such as volatility, organizational disturbances and regular reconfigurations of logistics networks, intensify the challenging effects of heterogeneity, because the differences encounter each other more often [Hoxha et al., 2010; Archer, 2006]. At the same time, heterogeneity leads to an insufficient communication. Which in turn leads to inefficiencies and a lower co-creational value [Rai et al., 2012]. The opposing characteristics of flexibility and heterogeneity result in an area of tension, hence logistics collaboration becomes a challenging issue for the Logistics Integrator. The core competency and business model of the LI comprises the bridging of the heterogeneity between the several LSP and their integration in order to provide flexible supply chains to its customers. While enabling the collaboration of different LSP, the LI faces the challenge of their integration that are described in the following subsection.

Challenges of Integration

Large logistics networks with a high amount of participating LSP imply a high heterogeneity of systems, processes, syntactical descriptions. Hence, the integration of several LSP particularly means the bridging of that heterogeneity. The alignment of multiple LSP is marked as a critical success factor [Langley and Long, 2016; Pfohl et al., 2013] in order to overcome the heterogeneity of integrated logistics networks or SCM, respectively. Precondition for this is the *compatibility* of resources from different LSP. Complementary resources and organizational compatibility are central issues for the success of collaborations [Ryu et al., 2009]. Next to physical compatibility of logistics resources, information compatibility and integration (in terms of information technology and information sharing) is crucial for collaboration in logistics. This comprises the cross-organizational connection of LSP on a low level, such as Business to Business (B2B) on the one hand [Hazen and Byrd, 2012; Hall et al., 2012; Prajogo and Olhager, 2012] and the engineering and management of the integrated flows of goods and information on a higher supply chain level in the context of the meta logistics perspective on the other hand [Rai et al., 2012; Hingley et al., 2011].

One promising approach to ensure flexibility and compatibility is the creation of modular logistics services [Rajahonka et al., 2013; Bask et al., 2010] as a common reference base. The increasing complexity in logistics networks demands for sophisticated IT and with the growing demand for flexibility on the domain level, flexible IT architectures, which are able to handle modular logistics services, are gaining importance as a common reference base [Scheuermann and Hoxha, 2012; Jörg Leukel, Jacob, et al., 2011; Helo and Szekely, 2005]. However, this has to be based on domain-specific knowledge about the logistics industry. The exploitation of logistics knowledge is already focus of several approaches in literature [Jörg Leukel, Jacob, et al., 2011; Helo and Szekely, 2005] whereas the structural and semantic differences remain to be a crucial issue [Franke et al., 2016; Scheuermann and Hoxha, 2012].

Furthermore, IT still remains an issue because of the still existing 'IT-gap' between the importance of IT services and the customer satisfaction with their provision [Langley and Long, 2018; Langley and Long, 2017; Pfohl et al., 2013]. While the participants of the Langley and Long [2017] study confirm basic transactional logistics services such as domestic transportation (86%) or warehousing (66%) to be already outsourced to LSP, only a minority of the participants outsourced IT services (17%) or LLP/4PL services (10%). The findings are confirmed by other studies as well [Langley and Long, 2016; Wilding and Juriado, 2004]. While Langley and Long [2017] state: *"Activities that are strategic, IT-intensive and customer-facing tend to be outsourced to a lesser extent"*, at the same time the studies of Langley and Long [2017] and Pfohl et al.

[2013] and other publications as well (e.g. [Fuchs and Otto, 2015; Rai et al., 2012]) indicate a growing importance of IT-integration and rather strategic logistics services to enable inter-organizational collaboration systems between the stakeholders of logistics networks (i.e. shippers, LSP, or even with competitors) in order to increase value co-creation, efficiency, and economic success.

Interim Conclusion

Summarizing, the logistics industry strongly depends on outsourcing and thus on effective collaboration of the involved LSP. Collaboration of the LSP means to arrange supply chains, that invoke resources and logistics services from different LSP. With the LSPs' inherent heterogeneity and the flexibility demanded by customers, there is a need for the business model of LI that integrates those LSP solving the field of tension between entailed heterogeneity and demanded flexibility. The LI's core competency is the integration of the informational flow between the involved LSP by bridging the heterogeneity. The precondition for bridging is a system of modular logistics services. The representation in IS is the crucial challenge of integration. This precondition is not satisfyingly fulfilled, as IT-intensive and complex logistics services remain to be outsourced to a lesser extent.

Cloud Principles - Flexible Usage of Virtualized Resources

Besides logistics specific drivers and success factors, there are further trends and paradigm shifts emerging in a more general business context. The trend of resource virtualization descends from a paradigm shift in IT-related aspects and results in the concept of Cloud Computing (CC). From this concept, basic cloud principles can be derived that are presented in the following.

Virtualization of IT-Resources

Today's industries and markets are facing an ongoing trend of virtualization and an ever increasing importance of electronic inter-organizational relationships, whereas higher expertise results in higher relational outcomes [Mallapragada et al., 2015; Brettel et al., 2014]. The paradigm of Service Oriented Architectures (SOA) [Erl, 2015] is actively supporting the realization of further virtualization. More precisely, this paradigm is focusing on a service as a *"scope of functionality that takes a defined input in order to produce a certain value for its consumer with a defined output by consuming a defined set of resources"* [Erl, 2015; Papazoglou and van Heuvel, 2006]. With such an abstract definition, services can be of diverse nature, such as business services or electronic services. SOA was originally designed for business information systems in order to align electronic services with business services by focusing on re-usable modular capabilities. Additionally, the basic ideas of service orientation were also transferred to physical assets and products. Thus, with the inherent 'servitization' [Baines et al., 2007; Morelli, 2003], the creation of Product Service Systems (PSS) [Beuren et al., 2013] is conducted. Business models are transformed by taking the provision of a capability to a consumer (i.e. service provision) into focus instead of selling the ownership of a particular physical product. The objectives are to increase competitiveness and profitability on the one hand [Geng et al., 2010] but also to increase sustainability on the other hand [Vezzoli et al., 2014]. Hence, business models become targets of changes, examples are: vehicle ownership structure in automotive industry (car sharing), bicycle sharing systems, or 'pay-per-wash' scheme of Electrolux [Barquet et al., 2016; Beuren et al., 2013; Kang and Wimmer, 2008; Williams, 2007].

Next to the mentioned fields of application, this virtualization of resources also strongly influences the field of (physical and non-physical) IT infrastructures and their provision. Based on service orientation, basic IT resources are usable without owning them and provided to the consumer '...-as-a-Service' [Q. Zhang et al., 2010]. Particularly, pure hardware resources (Infrastructure-as-a-Service (IaaS)), operation-ready IT system (Platform-as-a-Service (PaaS)), or software resources (Software-as-a-Service (SaaS)) are provided to customers on-demand under the notion of CC [Mell and Grance, 2011; Catteddu and Hogben, 2009; Vaquero et al., 2008]. This comprises distributed, virtualized IT resources that are dynamically reconfigurable by facilitated connectivity in order to meet optimized utilization of organizational IT systems. Central characteristics and benefits are outlined in the following list [Marston et al., 2011; Q. Zhang et al., 2010; Catteddu and Hogben, 2009]:

- highly abstracted, i.e. virtualized, resources
- resource pooling for a shared usage (hardware, database, memory, etc)
- immediate access to remote IT resources
- near instantaneous on-demand provisioning
- almost instantly scalable (up and down)
- high flexibility
- low cost of entry for initial usage, no upfront capital investment

Thus, the paradigm of cloud computing induced momentum to the notion of *service* as a basic unit of resource abstraction and thus to virtualization. Recent studies show an ongoing trend of IT outsourcing in terms of CC [Luftman et al., 2015]. However, CC as the progression and consequent development of SOA is not a new technological development itself as it is based on existing technologies, such as virtual machines, distributed computing resources, and web services. However, the specific bundling of those technologies, the creation of a customer-oriented business model, and the implementation of basic non-technical principles lead to the seminal paradigm of CC [Mell and Grance, 2011; Buyya et al., 2009; Vaquero et al., 2008].

Virtualization of Everything - The Cloud Paradigm

Beyond technological IT-related concepts, central characteristics and underlying concepts of CC - the *Cloud Principles* - can be interpreted in a more general way apart from IT systems [Delfmann and Jaekel, 2012]. On a coarse grained level, the principles mainly comprise (1) resource abstraction and virtualization, and (2) subsequent encapsulation within services. The goal of abstracting those principles is their application in other sectors in order to enable the characteristics and inherent benefits of CC in those other sectors as well. Services in general are inherently based on the usage of resources [Erl, 2015; Papazoglou and van Heuvel, 2006]. With their virtualization, resources of services can be made available on-demand and thus every service-based industry can be migrated to the cloud to a greater or lesser extent, depending on the characteristics[2] of resources. Thus, by enabling virtualized resources, an easier provision of services can be achieved and benefits of CC (e.g. resource pooling for shared usage, scalability, higher flexibility, and decrease of entry costs for initial usage [Marston et al., 2011; Q. Zhang et al., 2010; Catteddu and Hogben, 2009]) can be transferred to other sectors.

The paradigm of CC changed and shaped the landscape of the IT sector [Marston et al., 2011] and therewith business strategies, digitalization and business models of other industries as well [Bharadwaj et al., 2013] as the importance of IT and its strategical position is ever growing. Starting back in the days by being just a functional-level strategy that is 'aligned' but still subordinated under the business strategy, IT today is increasingly influencing business models, processes and products of companies. Thus, the role of IT strategy has to be re-evaluated in order to recognize the fusion of business and IT strategies in terms of a comprehensive 'Digital Business Strategy' [Bharadwaj et al., 2013]. Such a strategy comprises advanced information systems and digital cross-organizational collaboration. Hence, a transfer of cloud principles to the context of business and (production and/or service) industry is a logical step of progression.

Existing applications of cloud principles to specific fields comprise Cloud Value Systems [Jörg Leukel, Kirn, et al., 2011], Database-as-a-Service [Gropengießer and Sattler, 2014] and also an ad hoc approach to CC via Function-as-a-Service (FaaS) [Downie, 2016]. However, those approaches still focus on IT resources. Further approaches emerge that adopt those cloud principles to physical resources as well, like PSS did with the SOA principles. For instance, cloud manufacturing is the virtualization and provision of distributed manufacturing and production resources. It is found in literature under the term 'Manufacturing-as-a-Service' [Hofmann and Rüsch, 2017; Wu et al., 2013; L. Zhang et al., 2012; Xu, 2012; Rauschecker et al., 2011]. Even approaches introducing 'Everything-as-a-Service' (XaaS) [Duan, Fu, et al., 2015] that aim at a general service migration to the cloud [Duan, Cao, et al., 2015] can be found in literature.

[2] Production means like facilities and machines are bound to physical borders, hence an immediate provision of resources within seconds like in CC appears to be impossible.

Interim Conclusion

Cloud principles comprise the virtualization of resources and their encapsulation within reusable modules. There are approaches of adopting them to other fields. The cloud principles enable a high flexibility and the linkage of pooled resources of different providers. Hence, their adoption to the logistics domain appears to be an interesting approach in order to face the outlined challenges of collaboration in logistics.

Cloud Logistics - a Paradigm for Flexible Collaboration of Heterogeneous LSP

Certain parallels can be drawn between the services provided by LSP (e.g. transportation, warehousing, customs clearance) and the services provided under the label of CC (i.e. IaaS, PaaS, SaaS). Hence, the idea to adopt the described cloud principles to the field of logistics in general and to logistics resources in particular emerges in order to create the paradigm of *Cloud Logistics (CL)* [Delfmann and Jaekel, 2012]. With this, particular potentials arise from the parallels. However, there are also challenges emerging from the differences between logistics and CC.

Parallels Between Cloud Services and Logistics Services

Basic parallels between cloud services and logistics services can be drawn from their provisioning models as well as from their several characteristics. Those aspects are ranging from commodity-like, basic physical resources and their usage (e.g. IaaS in CC, transportation services in CL) to more sophisticated services comprising the coordinated usage of involved basic services (e.g. SaaS in CC, 4PL services in CL). Further parallels comprise the ongoing shift of business models from owning and operating own infrastructures of IT or logistics towards outsourcing them from external service providers [Luftman et al., 2015; Langley and Long, 2017]. As a consequence, modern logistics and IT departments fulfill rather coordinative functions, e.g. management of service providers and service levels, instead of particular planning and operation of own assets [Choudhary and Vithayathil, 2013], see Figure 1.5.

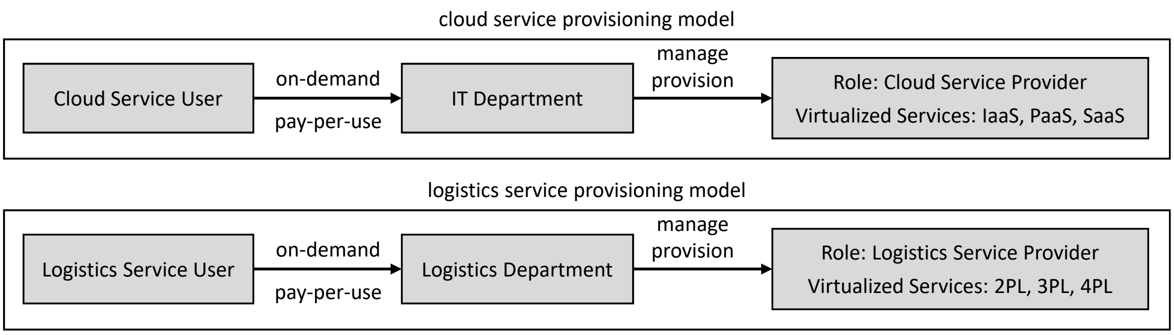

Figure 1.5: Cloud service and logistics service provisioning models, substantially extended from Choudhary and Vithayathil [2013].

Having a deeper look into principles and characteristics of cloud services and logistics services, further parallels as well as emerging challenges – of translating the cloud principles to the logistics domain – can be derived, see Table 1.1. As a consequence, it is standing to reason to evolve logistics towards a cloud-based paradigm.

Providing logistics services in a cloud like manner was first described in the white paper of Delfmann and Jaekel [2012] and the scientific paper of Holtkamp et al. [2010]. The latter focuses on the migration of the entire supply chain software to the cloud (i.e. PaaS, SaaS) and implementing a modular concept of 'business objects' in order to grant compatibility and consistency of IS and the alignment with physical logistics services. Alternatively, Delfmann and Jaekel [2012] recognized the potential of migrating not only IT resources to the cloud but also virtualizing physical logistics assets. By applying the cloud principles to *all* logistics resources, they have created the concept of a shared pool of compatible virtualized logistics resources that leads to a paradigm shift in logistics industry. Both, the virtualization of resources and their encapsulation in services, are essential to the paradigm; heterogeneity shall be bridged via a semantic approach [Delfmann and Jaekel, 2012]. However, their white paper only describes basic ideas without evaluations nor technical implementations. Since then, CL has been recognized as an emerging topic of future logistics in literature [Jaekel, 2019; Glöckner et al., 2017] and in industry as well, e.g. see DHL's annual logistics trend radar [Kückelhaus et al., 2016].

In [Glöckner et al., 2017] a comprehensive systematic literature review on 'cloud logistics' is presented. Following, a brief overview of the concept is outlined in order to give a general impression of the literature in this field of research. The detailed results can be found in Chapter 2. In terms of CL, there are other similar approaches with different namings as well as approaches that do not grasp the whole range of CL in terms of virtualizing *all* logistics resources. On the one hand, one approach with similar characteristics is e.g. Jörg Leukel, Jacob, et al. [2011] that introduces the concept of Supply-Chain-as-a-Service (SCaaS). They adopt the basic characteristics of CC to supply chain systems in terms of service description and composition. With a first evaluation use case, they deliver a proof of concept for describing and coordinating supply chain systems with the help of cloud principles. The approach lacks composing services and an integrated technology stack of specification language (such as Web Ontology Language (OWL)) in order to bridge the semantic gap between different LSP. On the other hand, there are publications that rather refer to an application of CC in the field of logistics instead of adopting basic cloud principles even to physical resources. For instance, Jede and Teuteberg [2016] develop a reference model for the usage of CC in supply chain processes. The integrated view of CL is missing, which means they only focus on the application of CC in the field of SCM instead of developing the idea of a pool of virtualized (physical) resources. Further, their approach lacks an in-depth reflection on semantical aspects of SCM or logistics.

Table 1.1: Comparison and translation of principles from cloud computing services to logistics services [Gudehus and Kotzab, 2012; Jörg Leukel, Jacob, et al., 2011; Delfmann and Jaekel, 2012; Mell and Grance, 2011; Vaquero et al., 2008]

Characteristics	**Cloud Services**	**Logistics Services**
User Access	Standardized interfaces and configurators for easy and transparent access.	Access is mainly a manual task. Easier self-access and reconfiguration can be achieved by adding standardized interface definitions.
Heterogeneity, Virtualization and Sharing of Resource	Interfaces hide the heterogeneity of hardware (e.g. CPU, storage) and software resources. Virtualization enables resource sharing by supporting compatible standards.	The actual operation of logistics services (e.g. transportation) is already target of outsourcing. By virtualizing the 'hardware' (e.g. trucks) and the 'software' (e.g. tools, and knowledge) of logistics, those resources can be hidden behind standardized interface. Hence, modular logistics service enable flexible usage and sharing of resources, especially of homogeneous assets like trucks or basic IT-systems (e.g. ERP, TMS).
Standardization	Standards support on-demand usage, easily accessing resources, enabling interoperability and scalability.	Logistics experienced changes and derived high benefits from standards, e.g. sea ship containers, EDI standards. However, the state of the art of conceptual standardization of logistics services, e.g. SCOR, lacks in usability because of being too generic and not adaptable.
Scalability and Resource Optimization	Cloud services scalability is based on virtualized resources and dynamic reconfiguration. Available physical computing resources limit scalability. Load-balancing follows dedicated rules that determine how resources are optimally shared between users.	Scalability of logistics services is based on adding further resources (e.g. trucks). However, this depends on standard interfaces that allow automated scaling by contracting logistics operators on demand. Scalability is limited by available resources (similar to IT), and further physical constraints (e.g. distance). Load-balancing and optimization of virtualized resources can depend on differing target functions, e.g. maximizing utilization of freight spaces.
Payment Model	Cloud services use a pay-per-use model relating to different SLA.	Logistics services use pay-per-use as well. This is based on distances, number of entities, or duration.
Service Level Agreements	Quality of services is guaranteed as defined in SLA. This forms an inherent feature of many cloud service offerings, e.g. Amazon. Customization results in different pricing models.	Logistics services are also available in different service levels. However, currently these service levels are outlined in arbitrary formats and bilateral contracts. Formalized SLA for logistics services would extend rapid contracting and resource allocation.

Potentials of Cloud Logistics

Several potentials arise when implementing the principles of the cloud logistics paradigm, which is the motivation for the current thesis. Essentially, the paradigm shift facilitates the coordination mechanisms of a specialized planning authority, i.e. Logistics Integrator (LI), that is keeping track of the whole supply chain. Through virtualization and encapsulation, modular logistics services can be created that enable the connection and on-demand usage of the underlying physical and non-physical logistics resources. Figure 1.6 depicts the basic approach of CL, with differing shapes of logistics resources at the bottom as the symbol for the heterogeneity of the LSP and the hexagons on top for the compatible resulting logistics modules connected within the fragmented logistics chain. Further, the virtualized logistics resources in the bottom of the cloud are modularized (depicted as hexagons) and clustered concerning their domain-specific purpose. The example shows 3 clusters: means of transportation, transshipment and warehousing, as well as picking and packing.

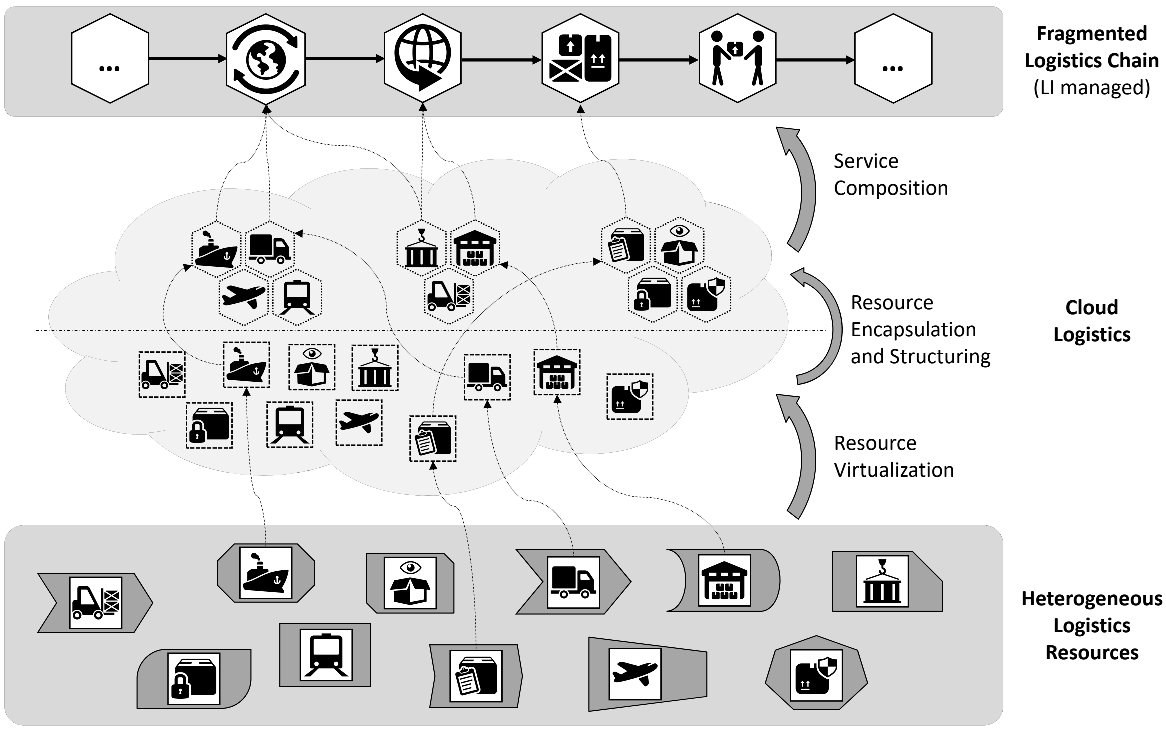

Figure 1.6: Resource virtualization and encapsulation within reusable cloud logistics service modules. Icons made by Freepik from www.flaticon.com.

With the help of cloud technology and cloud methods - or short: cloud principles - an easy implementation can be reached and the demand for digitalization and digital business strategies can be met as well. Further, it can help to increase the amount of outsourced IT services and strategic logistics services to the LI, while the other LSP focus on their core competencies, i.e. the actual physical operation of logistics networks, and shippers focusing on their core competencies, e.g. production or trade. Special focus has to be set on the syntactical gap of semantically equal service description, which literature suggests to be solved by semantic web or ontological approaches, e.g. see Jaekel [2019], Millet et al. [2013], Li et al. [2013], Delfmann and Jaekel [2012], Jörg Leukel, Jacob, et al. [2011], and Holtkamp et al. [2010]. Templates and reusable pattern of ontological descriptions can ensure the compatibility of LSPs' resources and their service descriptions despite the entailed heterogeneity. CL is assumed to address several of the top challenges [Langley and Long, 2016] LSPs' customers (the shippers) are facing, by reducing transportation costs, improving visibility, managing inventory, and achieving regulatory compliance. An increased transparency is the foundation and it is assured by the 'control tower' point of view of the LI. All those aspects are enabled by the paradigm of cloud logistics [Jaekel, 2019; Delfmann and Jaekel, 2012; Holtkamp et al., 2010].

Challenges of Cloud Logistics

However, challenges remain that have to be faced in order to successfully enable the above-mentioned potentials. Modular logistics platforms are based on compatibility between and alignment with existing physical and non-physical resources in the logistics network or supply chain, respectively. Besides the described similarities and the resulting potentials, the differences between CC and logistics impose a number of challenges. Well working communication is an important pre-requisit of logistics outsourcing [Wilding and Juriado, 2004]. This explains the low rate of outsourcing more complex and sophisticated logistics services that are rather strategic, IT-intensive and/or customer-facing [Langley and Long, 2017], as those sophisticvated services rely on a well working digital communication and information exchange. Another key challenge described by Kückelhaus et al. [2016] is the compatibility and integration of modular cloud services into supply chain management systems. Further, the granularity trade-off of modular services is a lasting issue [Steghuis, 2006]. Subsequently, compatibility as well as transparency about existing knowledge and resources require thoroughly developed approaches in terms of conceptual and technical IT-artifacts. Logistics service models need to be described similar to cloud services. Concepts and interfaces are currently not as compatible as in cloud computing. Further, resources virtualization and scalability cannot be utilized to full extend as service composition cannot build up on a stable description and structuring of services. Eventually, physical restrictions (space and time) impose an inevitable gap between service request and service provision.

Jaekel [2019] and Delfmann and Jaekel [2012] explicate the essential challenges of research on CL. A close synchronization between the physical and the virtual world is a necessary prerequisite. Interoperability of services between the individual resource pools is another crucial point. The necessity of a *Cloud Operator* for logistics, such as the LI, is discussed, which coordinates and moderates between the different stakeholders and defines, engineers and manages standards for service descriptions, data interfaces, and performance measurement or policies that ensure data privacy if sensitive customer information is shared during service delivery. Most important, a comprehensive service model based on logistics resources is required as well as concepts and technologies that facilitate the engineering and management of the resulting cloud logistics services. In the mean time, Jaekel [2019] has published a reference architecture design for cloud logistics, which sets a first referential framework without delivering concrete artifacts.

The research on CL is still a topic in its infancy [Delfmann and Jaekel, 2012]. The comprehensive systematic literature review about the state of the art of CL can be found in the course of the thesis in the first included paper, see [Glöckner et al., 2017] in Chapter 2, that develops a first scientific definition of CL by systematically reviewing existing literature on that topic. Apart from the definition, *conceptual* and *technical* foundations of cloud logistics are still missing in terms of comprehensive concepts on the *engineering* and *management* of cloud logistics services.

With regard to the syntactical gap, semantic building blocks, so called Ontology Design Pattern (ODP) [Hoekstra, 2009; Presutti and Gangemi, 2008; Gangemi, 2005], enable the creation of reusable ontological templates in order to overcome the semantic gap. Such an ODP represents the elementary body of a generic ontology for a specific purpose in order to give guidance for the creation and usage of ontologies in a specific field [Hoekstra, 2009]. Its reusable character and being the template for several services e.g. in a logistics network ensures the compatibility of the modular logistics services based on such a ODP. The modeling of the knowledge about the resources and services of a network in OWL as the semantic language offers several advantages: from explicit knowledge that is partially structured and modeled with classes and relationships, implicit knowledge can be deducted with the help of reasoning and inference techniques when needed [Negri et al., 2017; Giunchiglia et al., 2010]. Hence, the engineering and management of cloud logistics services, i.e. description, structuring and combination, can be approached with the creation of appropriate ODPs. Fundamental design principles and ontological building blocks of logistics in general and cloud logistics in particular are currently missing [Glöckner and Ludwig, 2017a] and thus constitute crucial research outcomes of the thesis.

Further, the modularization of logistics services demands for suitable granularity levels in order to facilitate decomposition of existing portfolios and composition of customized composite services. An appropriate conceptualization of service granularity is missing in literature [Glöckner et al., 2016b].

However, the described approaches are to be built upon artifacts developed from an inter-disciplinary perspective at the intersection of logistics and IT. The resulting particular objectives and research questions of the thesis are described in the following section.

1.2 Objective and Research Questions

The objectives of the thesis are the development and interrelation of conceptual and technical artifacts as designated research outcomes, which enable the engineering and management of cloud logistics services. They are domain-influenced and have the goal to bridge the semantic gap of LSP. Together, those artifacts form a conceptual framework used as a part of an information systems architecture in order to support a digital business strategy (see Bharadwaj et al. [2013]) regarding the emerging paradigm of cloud logistics. The artifacts are to be used to support the planning phases of complex logistics services' life-cycles (i.e. analysis and design, referring to Klinkmüller et al. [2011]).

The *engineering* of cloud logistics services, on the one hand, is based on a comprehensive, domain-influenced service model that enables the establishment of a flexible standard by a 'cloud operator' (e.g. LI) within a logistics network. Its purpose is to describe and virtualize physical and non-physical logistics resources in order to pool them, encapsulate them in services and thus to make them compatible in terms of reusable, modular cloud logistics services. For this part, the metaphor of the *service landscape* of a logistics network is used, that is described by the entirety of modular cloud logistics services that is existing in a logistics network. This supports the analysis and design phase of the lifecycle (i.e. creation of atomic cloud logistics services). Particularly the following artifacts are required for the engineering (and the addressing research questions in brackets):

- conceptual artifact describing a generic modular logistics service (see RQ_1)
- technical artifact (ODP) targeting the semantic of modular services (see RQ_2)
- conceptual artifact focusing on granularity of modular services (see RQ_5)

The *management* of cloud logistics services, on the other hand, is described by the metaphor of the *service map*. It is used to navigate in the above-mentioned landscape in terms of structuring cloud logistics service portfolios. Purpose is to enable an easy retrieval of specific virtualized and encapsulated logistics resources (above-mentioned modular cloud logistics services) from a catalog for the subsequent combination in order to create complex and customer-driven composite logistics services. The functions of structuring logistics services in order to facilitate retrieval and the function of combination of atomic services are comprised by the service map concept. This supports the design of composite logistics services. The structuring of services also faces the issues of service granularity. Those artifacts are supporting the design phase of the lifecycle (i.e. orchestration of atomic cloud logistics services). Particularly the following artifacts are required for the management:

- conceptual artifact describing the service map (structuring & retrieval) (see RQ_3)

- technical artifact (ODP) targeting the semantic structuring (see RQ_4)
- conceptual artifact focusing on granularity of modular services (see RQ_5)
- prototypical artifact as proof of concept (see RQ_6)

Based on the research objectives and the outlined artifacts, the leading question of the thesis (Q) is aiming at the development and description of the cloud logistics paradigm. Afterward, the leading question is split up into research questions (RQ_x) that are leading the content and structure of the included papers:

Q: *How can the paradigm of cloud logistics be described conceptually and complemented with technical artifacts in order to support the engineering and management of cloud logistics services?*

RQ_1: *How can the logistics domain and its essential resources be analyzed, described, abstracted and categorized in order to create a logistics service blueprint that enables cloud logistics?*

RQ_2: *How can essential aspects of logistics services be represented in an ontology design pattern?*

RQ_3: *How can a structure for a catalog of logistics services be developed conceptually?*

RQ_4: *How can essential structurings of logistics services be represented in an ontology design pattern?*

RQ_5: *What is the 'right' set of granularity levels for modular logistics services?*

RQ_6: *How can the concept of the Logistics Service Map be implemented prototypically?*

The leading question is split up into several research questions that each shape the structure of one of the included papers that form the body of the thesis. The first and second questions aim at the development of a conceptual and a technical artifact for logistics service engineering ('service landscape') whereas the third and fourth questions focus on the development of the conceptual and technical artifacts for logistics services management ('service map'). The fifth question leads to the conceptual framework of service granularity that links engineering and management. The sixth question focuses on the prototypical implementation of the developed service map concept.

The papers included in the current thesis are each focusing on one particular research question. The papers have been written based on the above-mentioned research questions, invoke several scientific research methods (as described later on) and have subsequently been peer-reviewed and published in several international scientific conferences and journals. The methodology of the comprising thesis' genesis as well as the methodological reflection of the papers' development and genesis are described in the following section.

1.3 Reflections on Research in IS and Logistics

Major Research Streams in Information Systems Research

Basically, there are two major research paradigms in IS [Hevner et al., 2004]: behavioral science and design science. The paradigm of behavioral science on the one hand is *reactive* and focuses on the behavior of humans and organization and seeks to explain and predict their behavior in terms of information systems that are regarded as *given*. The Design Science Research (DSR) paradigm on the other hand is *proactive* and focuses on the creation of *new* IS artifacts in order extend the capabilities of humans and organization [Hevner et al., 2004]. However, Hevner et al. [2004] emphasize the complementary character of both streams as the given systems need to be designed anyhow, and with the designed systems, new insights in the behavior of organizations and users can be deducted. Since CL is a research topic in its infancy [Delfmann and Jaekel, 2012] and only little research was done since [Glöckner et al., 2017], a behavioral research design on existing systems is not appropriate. Additionally, based on the artifact-focused research objectives, the thesis is following the IS research stream of *DSR*.

Hevner et al. [2004] are introducing the framework of *design science in information systems research* in order to grant rigor and relevance of research, see Figure 1.7. According the framework, IS research shall on the one hand take into account business needs as requirements from the practical environment in order to grant relevance and applicability of the results. Those requirements originate from the fields of people, organization and technology. On the other hand, theoretical insights from the knowledge base shall be used to guide either the design process itself by scientific methodologies and the designed outcome by scientific foundations. The application of the knowledge base grants rigor to the results.

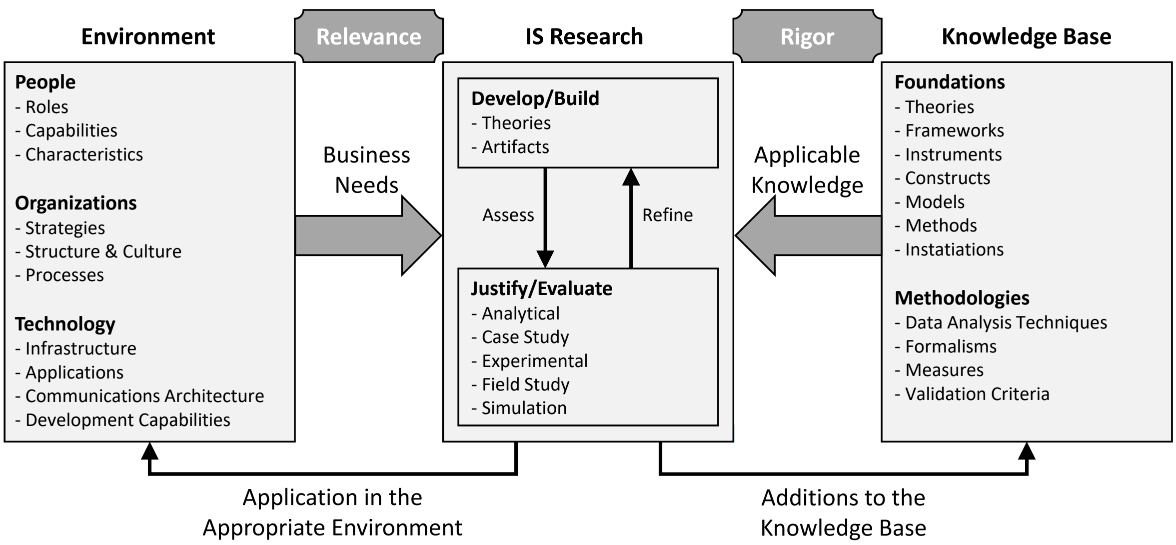

Figure 1.7: Information Systems Research Framework [Hevner et al., 2004].

The Role of the Artifact in DSR

The process of conception and construction is the essence of design science. This process implies the creation of a certain result that solves a previously specified design problem. The creation of such a result is the objective of the DSR approach. With the result-driven perspective, the creation of particular *artifacts* is in the center of all research efforts. The working definition of an *artifact* within this thesis is *"something that has, or can be transformed into [. . .] an artificially made object (e.g. model, instantiation) or process (e.g. method, software)"*, based on Gregor and Hevner [2013] with their reference to [Goldkuhl, 2002].

Even though, designing well-defined and concrete artifacts is crucial to the design oriented stream of IS, it has to be mentioned that a designed artifact consists of the designer's knowledge and understanding of the problem and solution. Hevner et al. thus explicate that *"in new and emerging applications of technology, the artifact itself represents an experiment"* [Hevner et al., 2004]. With this in mind, design knowledge (like from/for artifacts) evolves to design theory over time. Every maturation in a body of knowledge begins with new initial artifacts. Thus, Gregor and Hevner [2013] declare that even partial or incomplete theory as well as new design artifacts are important contributions to knowledge in new fields of research, by referring to [Merton, 1968; Sutton and Staw, 1995]. This view is further elaborated in [Gregor and Hevner, 2013], as every contribution of DSR, even design theory as presented in [Gregor and Jones, 2007], is characterized as a certain kind of artifact that matches a certain kind of knowledge maturity level. The resulting maturity levels of contribution types are adapted from the *outputs of design research* of Purao [2002] and displayed in Table 1.2, whereas lower level indicates more specific, limited and less mature knowledge. Higher level indicates more abstract, complete and mature knowledge. Novel artifacts, even level 1 contribution type artifacts, are valuable research contributions as they implicitly embody design ideas and theories that are not yet explicitly articulated, formalized and fully understood. With CL not being a very mature field of research yet [Delfmann and Jaekel, 2012; Glöckner et al., 2017], initial artifacts on first and second level scale of contribution type (see Table 1.2) are valuable contributions in order to increase maturity of research field.

Table 1.2: Deisgn Science Research Contribution Types [Gregor and Hevner, 2013].

Contribution Type	Example Artifacts
Level 3. Well-developed design theory about embedded phenomena	Design theories (mid-range and grand theories)
Level 2. Nascent design theory - knowledge as operational principles/architecture	Constructs, methods, models, design principles, technological rules
Level 1. Situated implementation of artifact	Instantiations (software products or implemented processes)

Knowledge Base in DSR

Knowledge in DSR can be of differing nature: either *descriptive* (denoted Ω or omega) or *prescriptive* (denoted Λ or lamda) in a science-philosophical context [Mokyr, 2002; Gregor and Hevner, 2013]. Ω knowledge comprises natural phenomena, as well as laws and regularities that are given and can be *discovered*. Its purpose is answering "what" questions. Λ knowledge, on the other hand, contains human-built constructs, models and methods that are created from human creativity. This knowledge cannot be discovered but is *invented* and has the purpose of answering "how" questions. By comparing research results in relation to the existing knowledge base (Ω & Λ), the novelty of new artifacts can be evaluated. These two knowledge bases are in close relationship and mutually important for each other [Varian, 2004]. With new insights in Ω knowledge, such as natural science, new possibilities emerge for the Λ knowledge, such as engineering. However, reciprocal analyzing Λ knowledge, and finding out why certain principles work, can lead to new insights, e.g. a particular rule set or natural phenomena, which leads to an extension of the Ω knowledge base. This mutual progression and evolution of knowledge over time as well as some examples of artifacts within the two bases are depicted in Figure 1.8. Further, this underlines the importance of initial and lower level artifacts in order to mature especially younger fields of research, such as CL. In the context of *relevance* issues, the research for new IS artifacts that are *invented* have to be lead by "how" questions and form Λ knowledge. To grant the new artifacts' *rigor*, which is to be ensured by a foundation on the existing knowledge base, "what" questions are invoked among others as sub questions derived from the leading "how" questions for subdividing the research concerning the developed artifacts.

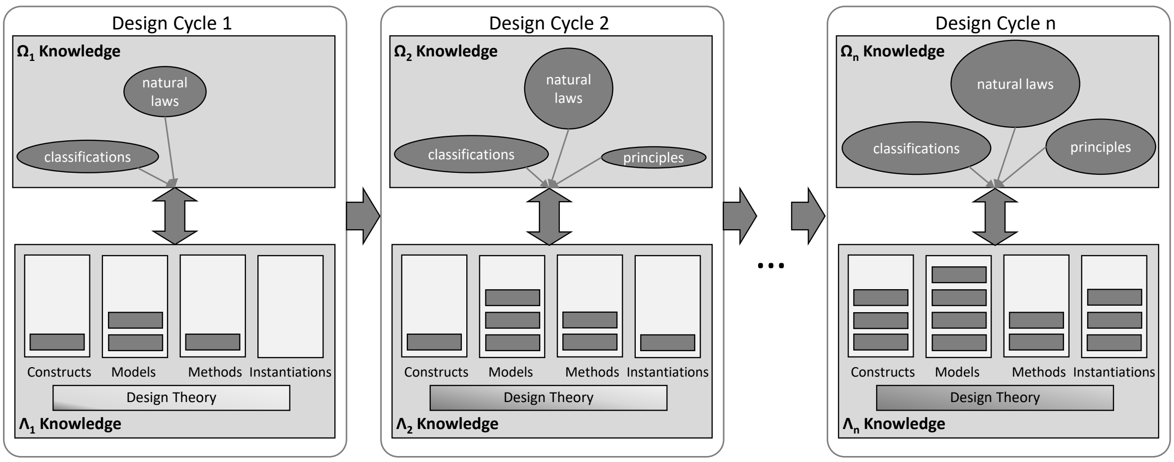

Figure 1.8: Cyclic Evolution of Knowledge, adapted from [Gregor and Hevner, 2013].

In order to understand and position contributions of DSR, Gregor and Hevner [2013] develop the *DSR Knowledge Contribution Framework*. Results are related to the starting point of the knowledge base in terms of *problem maturity* and *solution maturity*. Thus, the (incremental) progress and the contribution to the existing knowledge base can be indicated. Those dimensions of problem and solution maturity are comprised in a 2x2 matrix with problem maturity on the x-axis and solution maturity on the y-axis, see Figure 1.9. Contributions of the *Invention* quadrant mark a radical break through in research, especially in a context of little current understanding of the problems to be faced and where no effective artifacts exist in order to solve those problems. Thus, the conceptualization of the problem itself is considered a key contribution. Gregor and Hevner [2013] explicate that the majority of papers belonging to the invention quadrant represent an artifact at level 1 or 2 of the contribution type table rather than a fully developed design theory of level 3 (the several levels are described in Table 1.2). However, grand design theories usually build on a comprehensive base of already developed artifacts that all address one particular problem. Thus, the problem is known and contributions are not situated in the invention quadrant. The *Improvement* quadrant comprises publications and contributions that increase the effectiveness and/or efficiency of existing solution artifacts within a known application context. Mostly, those artifacts contribute to the Λ knowledge base. *Exaptation* contributions' objectives are the expropriation of existing artifacts in order to solve problems of adjacent and different fields of application. Existing design knowledge of one field is extended in order to solve problems of another field of application. Last, applying existing solutions to known problems leads to *Routine Design* which normally does not contribute to the knowledge base of DSR. In order to further support the process of producing and consuming knowledge in DSR, Gregor and Hevner [2013] outline a *DSR Publication Schema* that consists of (1) Introduction, (2) Literature Review, (3) Method, (4) Artifact Description, (5) Evaluation, (6) Discussion, and (7) Conclusion.

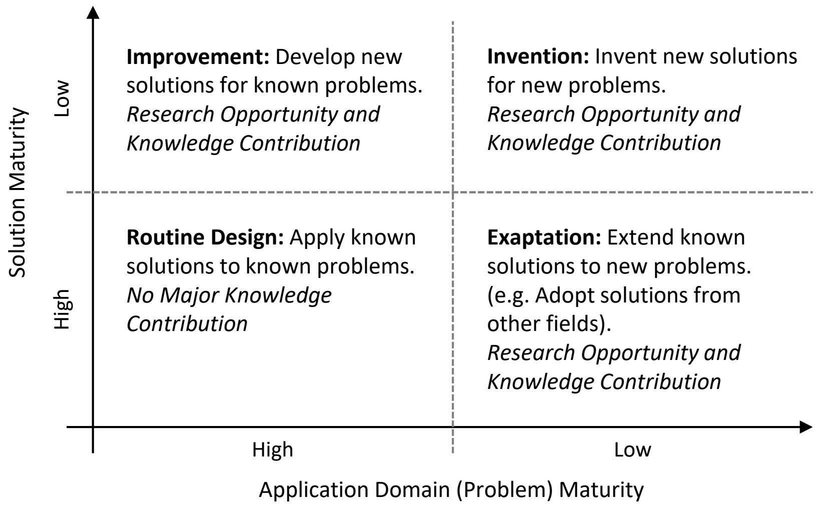

Figure 1.9: Design Science Research Knowledge Contribution Framework [Gregor and Hevner, 2013].

This framework is also expression of the issue that nothing in science appears to be *"really 'new'"* [Gregor and Hevner, 2013]. Every scientific contribution is based on previews work and is created out of existing contributions and thus in the majority of cases publications and research results establish 'just' incremental progress.[3] Fields with a low knowledge maturity in particular benefit even from incremental improvements or only partial theory building as a significant publishable contribution.

Scientific Rankings - Tell me what's it good for?

In general, scientific rankings are used as 'scientific quality indicator' in order to (1) give guidance to authors on where to publish their work and (2) to assess and rate publications by the reputation of the publishing outlet they appeared in. Rankings are either based on a ordinal scale (e.g. the VHB Jourqual 3 ranking[4] (with a scale from A^+ to D)) or on a ratio scale with a point of origin and measurable indexes (e.g. the measurement of the h-index [Hirsch, 2005]).

On the one hand, this is discussed as an advantage as a ranking-based assessment seems to be reasonable when facing and structuring the ever increasing plethora of possible publication outlets and scientific venues, i.e. journals and conferences. Further, purposes of publication rankings are such time-critical and sometimes non-expert contexts like committees hiring, promoting and retaining faculty members; or librarians investing limited acquisition funds [Chapman and Ellinger, 2009; Shugan, 2003; Walstrom and Hardgrave, 2001]. However, on the other hand, there are several members of the scientific community that observe the higher and increasingly sole importance of rankings with suspicion. Hicks et al. [2015] state in a comment in the high reputation journal *Nature* that *"the abuse of research metrics has become too widespread to ignore"*. The informed judgment of publications, i.e. actually reading and valuing papers, can never be replaced by relying on a single indicator. This general criticism and discussions of the natural science community can also be found in the management science community, e.g. see [Lorenz and Löffler, 2015; Brown, 2012; Kieser and Osterloh, 2012; Nkomo, 2009], as in the IS research community, e.g. see [Willcocks et al., 2008; Agarwal and Lucas, 2005], and in the logistics research community as well, see [McKinnon, 2017; McKinnon, 2013]. In IS research, the discussion on rankings is strongly related to the discussion of the identity crisis of IS [Agarwal and Lucas, 2005] as an interdisciplinary field of research with a strong connection to an application environment (as a source of problem and user of the resulting IT artifacts).

As outlined in the discussion, rankings affect the research landscape. Research activities in IS are narrowed in order to publish within high-impact journals to gain visibility by the price of disregarding innovative and new fields of development and construction of broader meaning of the IS research field [Agarwal and Lucas, 2005]. When journals

[3] This point of view itself is also not a new insight. The metaphor of *"dwarfs standing on the shoulders of giants"* is dated back to the 12^{th} century and was made popular by Isaac Newton in 1675 [Newton, 1675]. The dwarfs (modern scientists) are able to look further because of being elevated by the giants (previous scientists and their research contributions). However, as they are dwarfs, they are only able to look a little bit further (incremental progress of science and research).

[4] http://vhbonline.org/vhb4you/jourqual/vhb-jourqual-3/teilrating-wi/

of adjacent research fields such as sociology are assessed, biased ratings result from differing stats and foci [Willcocks et al., 2008]. McKinnon outlines the damaging effect of rankings and their over-interpretation for logistics as an academic discipline in the papers *Starry-Eyed I* and *II* [McKinnon, 2013; McKinnon, 2017]. Especially logistics as a rather young, small, application-oriented and itself interdisciplinary field of research suffers from the described effects. For instance: researchers in the interdisciplinary field of logistics and IS are forced to publish in journals of the related IS field in order to anyhow get the possibility to even publish in A^+ Journal in accordance to the VHB rating as this particular rating does not rate any logistics journals with A^+. A self-perpetuating cycle results in terms of submitting top papers only to top journals, preventing mediocre journals, such as most logistics journals [McKinnon, 2013], from becoming top journals in order to receive high quality papers from the community. McKinnon draws three main consequences from his discussion of *logistics research* in the context of rankings: (1) there are difficulties of gaining respect, reputation, funding and even career perspectives in comparison with other faculty of fields with a broader ranking range of journals; (2) logistics researchers reacting to this and publishing in the top-tier, i.e. non-logistics, journals reinforce this status quo; and (3) methodological bias towards theoretical and mathematical papers of the top logistics journals (remark: again, even those are not A^+-ranked) cuts off papers of alternative research streams, such as empirical, survey- and case-study-based as well as design science papers.

Indeed, a highly charged debate can be pursued either for or against rankings and how to use and rely on them[5]. No consensus can be found between different rankings, which is no direct disadvantage itself as different rankings are based on different opinions and criteria and thus each can have their own right to exist. However, with the existing opacity about criteria and subjective opinions, opacity exists about the finding of the final ranking and/or rating. Thus, rankings can be used at most as rough guidelines. As Willcocks et al. [2008] summarize, it remains essential to actually read publications and to put papers and research outcomes into the context of an overall research strategy in order to assess each output independently from rankings.

1.4 Outline and Structure of the Thesis' Contributions - Included Publications

After the reflections on methodological aspects and rankings, the following section puts the current thesis in context to those reflections, outlines the relation to adjacent research streams as well as the relations between the papers and their inherent artifacts that are based on the research questions presented in 1.2.

[5] In this context, even scientists lose their academic dignity and adopt the wrong tone as in the debate between [Willmott, 2011; Rowlinson et al., 2015; Tourish and Willmott, 2015] that is summarized in the introduction of the paper *Starry-Eyed II* of McKinnon [2017].

General Contribution Type Level and Knowledge Contribution

The field of Cloud Logistics is an interdisciplinary research issue with relations to different areas of research, see Figure 1.10. On the one side (right), logistics provides a problem in terms of a new business model. Even though the idea of an LI, or 4PL respectively, is not that new, the problem maturity remains low as suitable concepts for the implementation are missing on the practical as well as on the scientific side. On the other side (left), different IS disciplines provide basic approaches for first solution ideas of the CL issues. Those particular approaches are either of high maturity, e.g. ODP, or SOA, or they are of low maturity, e.g. cloud principles and service engineering of hybrid physical and informational services such as logistics services. Hence, the artifacts contribute in different ways to the current knowledge base, see Table 1.3 and for explanation Figure 1.9.

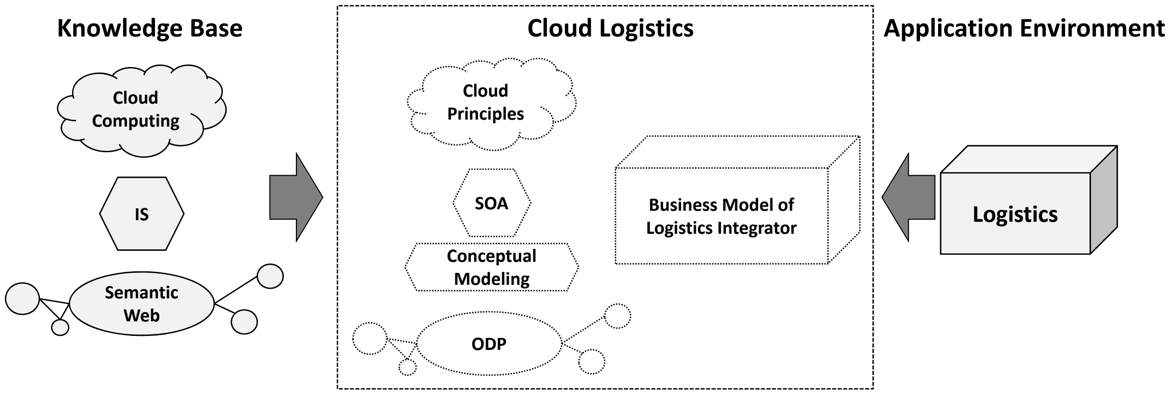

Figure 1.10: Cloud Logistics and its influencing research streams.

CL itself is a relatively young field of research with a low maturity of problems and solutions, as a systematic description of several issues (e.g. the metaphors of landscape and map) first had to be conceptualized (see 1.1). Accordingly, the whole approach of *foundational research artifacts of Cloud Logistics* described in this thesis can be considered an *invention* in terms of knowledge contribution. According to the knowledge contribution of an invention, its first development and description only reaches to the second level of contribution type: *nascent design theory*, i.e. knowledge as operational principles/architecture.

The thesis follows the guideline of [Gregor and Hevner, 2013] and presents the seven suggested aspects: (1) The purpose and scope are described in the first chapter in terms of a brief introduction into the field of logistics and the resulting approach of cloud logistics. (2) Related approaches are briefly outlined and a reference is given to the first included paper of the thesis that contains a systematic literature review. (3) The thesis is related to an the IS research stream of DSR and further methodological reflections are presented. (4) Artifacts are described in the invoked papers of the following chapters. (5) The evaluation of the total approach is described in the last chapter. (6) discussion and (7) conclusion complete the thesis at the end.

Applied Methodological Framework and Integrated Methods

The actual research process within the DSR research framework is of iterative nature [Hevner et al., 2004]. Theories and artifacts are to be designed based on the foundation of relevance and rigor in the step *develop/build*. Afterwards, the step of *justify/evaluate* is conducted to analyze and assess the designed artifact and to gain new insights for further development. Gregor and Hevner [2013] refer to the outlined steps of Peffers, Tuunanen, et al. [2007] in their generic method for DSR: (1) identify problem; (2) define solution objectives; (3) design and development; (4) demonstration; (5) evaluation; and (6) communication. Moreover, Gregor and Hevner [2013] show further refined and developed methodologies, such as the methodological research framework of Österle, Becker, et al. [2011]: the *memorandum on design-oriented information systems research*. This framework clearly focuses on the scientific development of artifacts and guides the research process by defining four distinct basic phases that are to be (iteratively) proceeded in order to generate those artifacts [Österle, Becker, et al., 2011; Österle, Winter, et al., 2010], see Figure 1.11. Referring to the steps of Gregor and Hevner [2013], step (1) and (2) are joined to *analysis*, and steps (3) and (4) are merged into *design*. Evaluation and communication, or diffusion respectively, are equal. By passing through the entire cycle, a rigorous development of relevant resulting artifacts can be granted. The invocation of appropriate scientific methods within each phase of the cycle in particular ensures the quality of the developed artifacts. The phases are described and the research methods that have been used in the thesis and applied during the course of the phases are listed. The methodology of design-oriented IS research comprises the following four phases [Österle, Becker, et al., 2011; Österle, Winter, et al., 2010]:

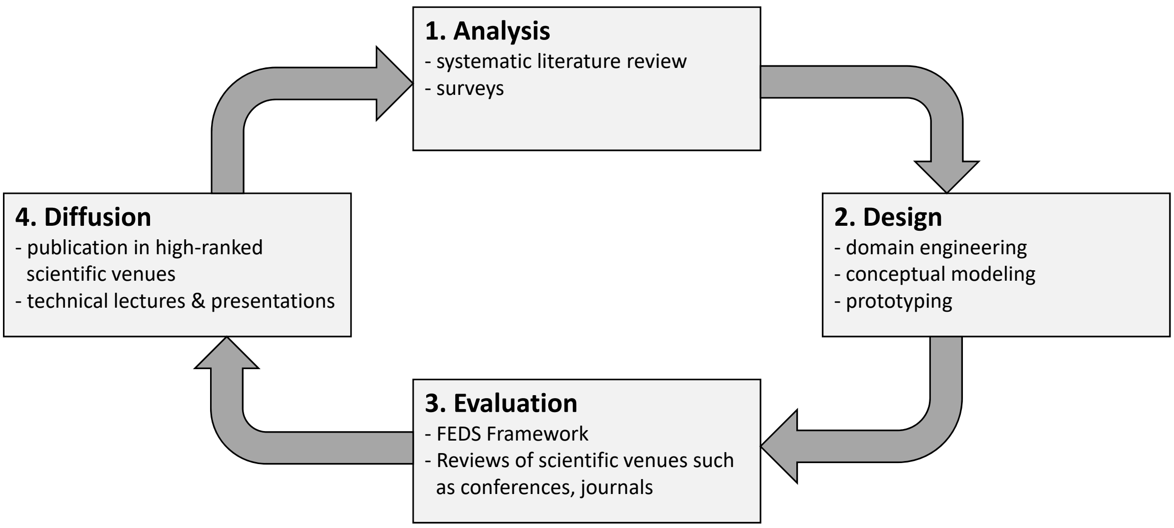

Figure 1.11: Framework of design-oriented IS research [Österle, Becker, et al., 2011]. Phases are complemented with example methods in this figure.

1. Analysis: The first phase comprises problem identification and description in order to grant relevance of the research outcomes. The research gaps, objectives, and questions are derived and specified. The state-of-the-art, existing solutions and their shortcomings as well as methods for the solution of the problem are analyzed and outlined in order to grant rigor. Further, the invoked research methods are planned, described and configured. Empirical studies are used in order to describe the actual context of the logistics domain in general and the situation of LSP in particular. The invoked research methods of this phase, which were applied to create the developed artifacts, comprise:

- systematic literature reviews [Vom Brocke, Simons, Riemer, et al., 2015; Kitchenham and Charters, 2007; Webster and Watson, 2002]
- surveys [Fowler, 2013] that are conducted within studies on the field of interest by other researchers or institutions

2. Design: Generally accepted (published) methods are to be planned and used. Design decisions are to be justified. Advantages to existing solutions are to be outlined. The design phase comprises all methods that are used to actually create new artifacts. The invoked research methods of this phase that are used to develop the artifacts of the thesis comprise:

- extended service blueprinting [Hara et al., 2009]
- domain engineering [Czarnecki and Eisenecker, 2000]
- general morphological analysis [Ritchey, 2013]
- NeOn methodology [Suárez-Figueroa et al., 2012]
- conceptual modeling [Embley and Thalheim, 2011]
- metamodeling [Atkinson and Kühne, 2003]
- prototyping [Holmes, 2016; Wilde and Hess, 2007; Lantz, 1986]
- method engineering [Ralyté and Rolland, 2001; Castano and Antonellis, 1993]

3. Evaluation: The developed artifacts are to be validated against specified objectives with the method outlined in the planning. The review process of scientific journals and conferences is explicitly denoted as being a part of the evaluation process as well [Österle, Becker, et al., 2011]. The venues of publication are all carrying out a strict double-blind peer-review system without exception. The reviewing and approving venues are presented in the upcoming section 1.4. The invoked research methods of this phase used in the course of the included papers comprise the following ones:

- Framework for Evaluation in Design Science (FEDS) [Venable et al., 2014]
- Design Science Research Evaluation [Peffers, Rothenberger, et al., 2012]

4. Diffusion: The dissemination of the research outcomes is one of the most important points of the framework in order to create a research community of vivid exchange. Appropriate formats of diffusion are scientific paper, conference paper, oral presentation and dissertation theses. There are no particular methods for diffusion itself. However, the used venues of publication are presented in the upcoming sub-section.

Included Papers - Structure and Relation

Each artifact either answers one of the research questions (see section 1.2) (artifacts #1 - #6), presents an application example (#7), or consolidates (#8) the basic artifacts. Each artifact passed through the described cycle of the *memorandum*, and was published within a particular paper[6]. The papers invoke certain research methods in order to design the artifacts. An overview of this can be found in Table 1.3 with the ID of each artifact, the corresponding artifact's name, the leading development method as well as a classification based on the contribution type level (see Table 1.2) and the kind of knowledge contribution (see Table 1.9).

Table 1.3: Contributions of the thesis.

#	Artifact	Leading Method	Level	improvement	exaptation	invention
1	Landscape (Conceptual)	Extended Service Blueprinting	2			x
2	Landscape (Technical)	NeOn Ontology Engineering	2		x	
3	Map (Conceptual)	Metamodeling	2		x	
4	Map (Technical)	NeOn Ontology Engineering	2		x	
5	Granularity Framework	Systematic Literature Review	2			x
6	Prototype	Prototyping	1		x	
7	Application Example	Method Engineering	2	x		
8	Consolidation & Roadmap	DSR Framework	3			x

The publication of scientific papers is linked to a particular venue, which could be either a scientific conference and its corresponding proceedings or a scientific journal. An overview of the venues and publication outlets of the thesis' papers and their ranking is given in Table 1.4. Besides the acronym in the table, the full name of the venues is given in the corresponding executive summary in the subsequent chapter of each paper.

As discussed before, scientific rankings of publication outlets are to be taken into account responsibly, as their meaningfulness is limited. Nevertheless, in order to give rough guidelines for the assessment of the included papers, two rankings and one index are chosen. In consequence of the low maturity of the research topic of the current

[6] Except for the consolidation paper #8 that mainly contains the already published artifacts and sets them in relation to each other, and is publication ready.

Table 1.4: Publication venues of the included papers.

#	Artifact	Paper Types	Venue	CORE	JQ3	h-index
1	Landscape (Conceptual)	Conference Paper Proceedings	HICSS	A	C	-
2	Landscape (Technical)	Workshop Paper* Book Chapter	ISWC	A	-	-
3	Map (Conceptual)	Conference Paper Book Chapter	BIS LNBIP	B	C	27
4	Map (Technical)	Conference Paper Workshop Paper**	WI-IAT ISWC	B A	-	-
5	Granularity Framework	Conference Paper Proceedings	ECIS	A	B	-
6	Prototype	Conference Paper Book Chapter	DESRIST LNCS	A	C	251
7	Application Example	Conference Paper*** Book Chapter	ICEIS LNBIP	C	C	27
8	Consolidation & Roadmap	Journal Paper	publication ready	-	-	-

* The publishing of ODP through the 'official' community is bound to the annual *Workshop on Ontology and Semantic Web Patterns* (WOP): http://ontologydesignpatterns.org/wiki/WOP:Main

** A short version of the conference paper was also presented at WOP'17 like paper #2.

*** Best-Paper-Award at the ICEIS'15: http://www.iceis.org/PreviousAwards.aspx#2015

thesis, the first resulting research artifacts are also of low maturity (see the cyclic evolution of knowledge in DSR adapted from [Gregor and Hevner, 2013] in Figure 1.8) and thus conferences are more likely to become first publication outlets in order to present initial results to the community and gain feedback for further improvement. Thus, the *CORE rankings portal* from 2018[7] is chosen; it focuses on conferences in the field of computer science and information technology, even specialized fields such as semantics are covered. The CORE rating is based on a mix of indicators, such as citation rates, paper submission and acceptance rates. Further, the VHB ranking list *Jourqual 3 (JQ3)* from 2015 is chosen; it is based on a survey among over 1000 researchers with a general perspective of management science and economics but also specialized fields, such as IS and logistics, are included in the consortium and thus specialized part rankings exist[8]. The phenomena of a low average rating of logistics journals [McKinnon, 2017] can be recognized as well[9]. The JQ3 ranking mainly focuses on journals but especially in the IS part ranking the main conferences and their respective proceedings

[7] http://portal.core.edu.au/conf-ranks/

[8] http://vhbonline.org/vhb4you/jourqual/vhb-jourqual-3/gesamtliste/ with two part lists for the both concerning fields of IS (http://vhbonline.org/vhb4you/jourqual/vhb-jourqual-3/teilrating-wi) and logistics (http://vhbonline.org/vhb4you/jourqual/vhb-jourqual-3/teilrating-log/).

[9] In the logistics part of the JQ3 ranking, there is not a single A+ ranked journal and only three A ranked journals but all of them three with a strong focus on mathematical modeling

are included and ranked as well. Hence, the CORE and the VHB ranking constitute useful options. Further, the h-index from Scimago[10] is taken into account, stating the amount (h) of a journal articles that have received an amount of at least h citations, as proceedings of some of the conferences are published as listed journals.

For papers 1 and 5, there are no distinct journals but the conference proceedings are ranked in JQ3. Papers' 3 and 6 conference proceedings are published directly within Springer's series *Lecture Notes in Business Information Processing (LNBIP)* and *Lecture Notes in Computer Science (LNCS)*, respectively. Paper 7, as one of ICEIS 2015's best papers, was chosen to be published in a revised and extended version in LNBIP. The relationship between the papers is outlined in Figure 1.12 that contains all eight listed papers that are included in the thesis as well as three further papers, which are related to the field of research but not part of the thesis itself. The two main issues of service engineering and management, the service landscape and the service map, are described conceptually at first (#1 and #3). Afterward, the respective ontological technical artifacts are presented in order to achieve compatibility of resources from different LSP (#2) and their structuring (#4). Both, engineering and management, depend on a clear service granularity that is conceptualized in paper #5. The engineering and management of modular logistics services is prototypically demonstrated in paper #6 as a junction of the engineering and management functionality. In paper #7, an application example is given that describes a method that invokes the service map approach in order to prepare for automated generation of complex service alternatives with subsequent automated evaluation of the alternatives by a simulation approach. Finally, paper #8 consolidates all the basic artifacts of cloud logistics and draws attention to future research issues.

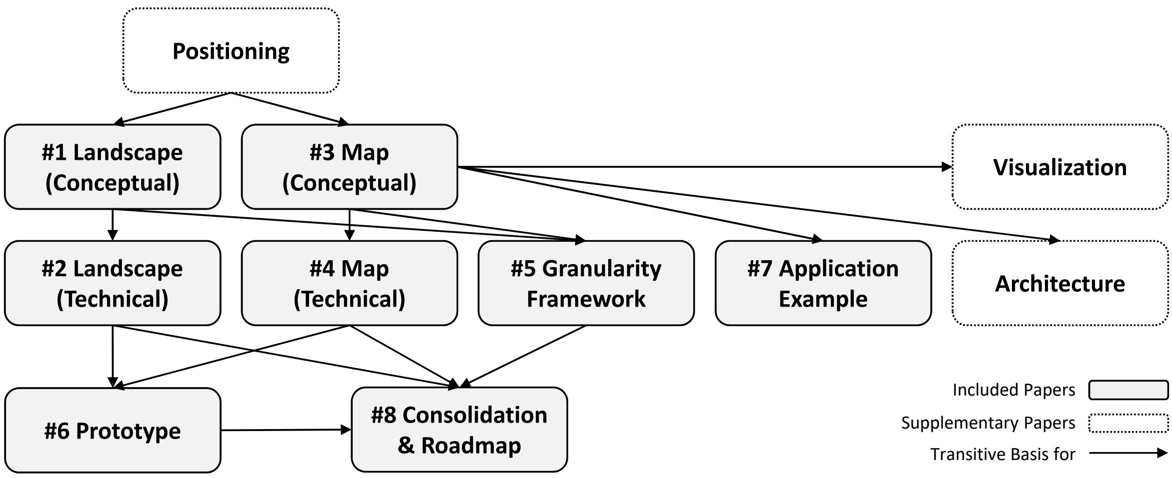

Figure 1.12: Included and supplementary Papers and their relation.

Apart from the included publications, further papers in the context of service engineering and management in logistics were published. The positioning paper [Glöckner and Ludwig, 2013] contains the basic conceptual idea of the logistics service map as an

[10] http://www.scimagojr.com/

approach of integrated engineering and management of logistics services. In [Glöckner, Schwarzbach, et al., 2014], issues of the visual design of the service map are analyzed and aspects of cognition and visualization are taken into account in order to facilitate the management of logistics services and improve usability. Those findings influenced the development of the prototype as well. The Paper of [Glöckner et al., 2016a] presents a first attempt to create a reference architecture of the logistics service map.

Papers are included just as they were published. This further implies a mixture of layout and citation styles, as different conferences and journals provide and prefer different templates and styles. For each paper, an additional executive summary outlines the main contribution of the paper, the relation to the thesis as well as the meta data. The following eight sections are dedicated to the described papers that document the research on the foundational artifacts of cloud logistics.

2 Landscape - Conceptual

Glöckner, Michael; Ludwig, André; Franczyk Bogdan (2017): Go with the Flow - Design of Cloud Logistics Service Blueprints. In: Proceedings of the 50th Hawaii International Conference on System Sciences (HICSS) 2017, Waikoloa, Hawaii, United States of America. [Glöckner et al., 2017]

2.1 "Go with the Flow - Design of Cloud Logistics Service Blueprints"

Table 2.1: Meta data of the publication (Landscape - Conceptual).

DOI	10.24251/HICSS.2017.614
URL	https://scholarspace.manoa.hawaii.edu/handle/10125/41776
Type	Conference Paper, Proceedings
Publication in	Proceedings of the 50th Hawaii International Conference on System Sciences (HICSS) 2017
Editor	-
Series Title	Proceedings of the Hawaii International Conference on System Sciences
ISSN / ISBN	978-0-9981331-0-2 (ISBN)
Publisher	-
Place of Publication	Waikoloa, Hawaii, United States of America (HICSS 2017)
Ranking	CORE: A-ranked (conference) VHB: C-ranked (proceedings) h-index: -

Proceedings of the 50th Hawaii International Conference on System Sciences | 2017

Go with the Flow - Design of Cloud Logistics Service Blueprints

Michael Glöckner[1,2], André Ludwig[2], and Bogdan Franczyk[1,3]
[1]*Leipzig University, Leipzig, Germany*
[2]*Kühne Logistics University, Hamburg, Germany*
[3]*Wrocław University of Economics, Wrocław, Poland*
{gloeckner, franczyk}@wifa.uni-leipzig.de — andre.ludwig@the-klu.org

***Abstract*—By adopting principles of cloud computing to the logistics domain the paradigm of Cloud Logistics is derived. It appears to be a promising paradigm in order to evolve logistics into being more flexible and collaborative. Yet, appropriate concepts that enable the cloud logistics paradigm are missing. In the paper, existing body of literature is reviewed and a definition and a framework of cloud logistics is given. Further, service blueprinting is combined with domain engineering and general morphological analysis in order to create a suitable method for designing cloud oriented service blueprints. Those are focusing on domain-specific flows and transformations enabling cloud oriented business collaboration. The method is applied to the logistics domain and a cloud logistics service blueprint is designed. Finally, the concept is evaluated with real use cases from logistics service providers.**

***Keywords*-Logistics, Service, Blueprinting, Cloud Logistics, Resource Virtualization, Service Encapsulation**

I. Motivation and Methodology

For years, logistics is facing the trends of outsourcing and concentration on core competencies [1], [2]. In order to fulfill complex customer demands in such an environment of specialized logistics service providers (LSP), selection of and collaboration between them is obligatory. For the selection of LSP, flexibility - in terms of ability of adaption to changing customer requirements, responsiveness to target market, handling of specific requirements and time response capability - is an important evaluation criteria [2], [3], [4]. Flexibility and performance of logistics services can be increased [5] by the adoption of a service oriented paradigm [6], [7], which is also the foundation for the principles of cloud computing (CC) ('...-as-a-Service') [8], [9]. This comprises on the one hand *encapsulation*, composability, loose coupling, and reusability (adapted from service orientation) and on the other hand *virtualization of resources*, ad-hoc reconfiguration and inter-connectability of resources (adapted from CC). The adoption of those principles to the logistics domain to the most possible extent leads to the idea of *Cloud Logistics* (CL) as discussed in [10]. Its core idea is the virtualization of both IT and *physical* logistics resources and their encapsulation in logistics services in order to provide flexible and customized logistics solutions.

It is pointed out, CL is still a topic in its infancy, just existing as an theoretical concept and potential fields of further research are discussed [10]. The most promising field is a comprehensive service model based on logistics resources and ensuring compatibility through coherent (data) interfaces, which is crucial in order to combine services and resources of different LSP. This conforms to the results of Gupta et al. [11] and Arnold et al. [12]. They found simple communication between stakeholders, ease of use and convenience (which are enabled through comprehensive models and compatibility) to be the topmost success factor of CC ([11] for small and medium enterprises in general and [12] for logistics enterprises in particular). Hence, those factors are assumed to enable the success of CL as well.

Ease of use through compatibility and a comprehensive model can be provided by a modular construction kit [13] that is based on generic compatible building blocks that represents the comprehensive service model. Thus, the idea of Cloud Logistics Service Blueprints (CLSB) arises that can be configured and specified to virtualize and represent the various logistics services in a network and their resources. By virtualizing and encapsulating with the help of the same CLSB, compatibility of services and their resources is granted and CL is enabled. Eventually, the engineering of such a blueprint is a challenging task that answers the leading research question: *'How can the logistics domain and its essential resources be analyzed, described, abstracted and categorized in order to create a logistics service blueprint that enables cloud logistics?'* that is solved with the following sub-questions:

- SQ_1: What is the leading definition of cloud logistics?
- SQ_2: What are suitable service engineering methods for creating cloud oriented service blueprints?
- SQ_3: What is an appropriate conceptualization of the logistics domain (description, flows, interfaces, transformations) in order to develop Cloud Logistics Service Blueprints for enabling cloud logistics?

As CL is a theoretical concept [10], an empirical observation is not possible. Hence, the design-science paradigm for information systems [14] is chosen and the design-oriented information systems research approach [15] is applied as the leading methodological framework. Its phases of analysis, design, evaluation and diffusion shape the structure of the paper by using specific methods, see Figure 1. The *analysis* is conducted in section II with a systematic literature review

URI: http://hdl.handle.net/10125/41776
ISBN: 978-0-9981331-0-2

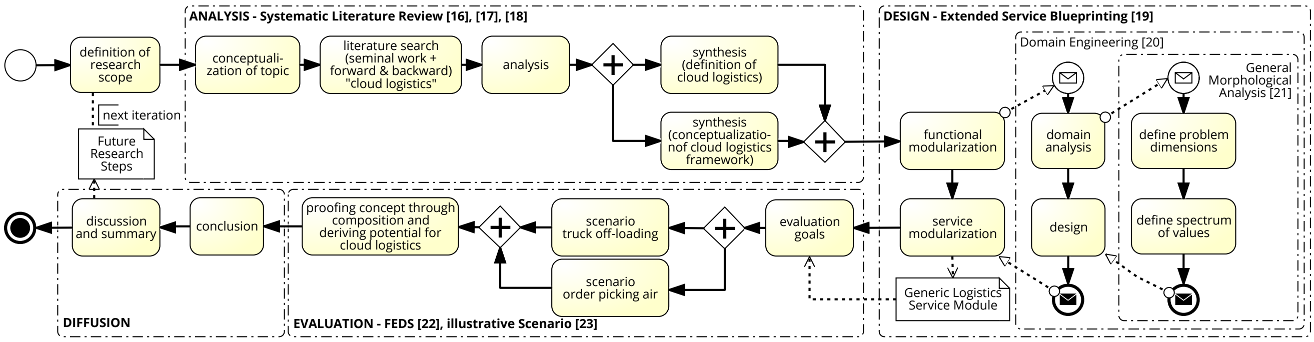

Figure 1: The design-science paradigm [14] as leads the design oriented research frame [15] with invoked methods.

that follows the approaches of [16], [17], [18]. It reveals the state of the art of current literature concerning the concept of 'cloud logistics' in order to develop a thorough theoretical basis. In times of ever increasing amount of scientific papers being published and being accessible in seconds via electronic databases and the internet, it gets more difficult to accomplish a comprehensive analysis and synthesis of literature due to limits of human perception and processing of information. Hence, Vom Brocke et al. [16] argue for the strategy of finding publications in a field with the most seminal character as the 'backbone' of the body of literature that is broaden by forward and backward search subsequently. The *design* phase in section III focuses on the development of a suitable method for designing cloud oriented service blueprints. The comprehensive method involves mainly the methods of 'extended service blueprinting' [19] as the leading approach, 'domain engineering' [20] in order to find common and varying points of a domain and to create a configurable architecture. The 'general morphological analysis' [21] is invoked in order to structure the multidimensional problem complex and to create a morphological field. After being described, the comprehensive method is applied to the logistics domain in order to develop the CLSB. For *evaluation*, in section IV the resulting CLSB concept is applied to services abstracted from real world processes of internationally operating LSP and evaluated with the 'Framework for Evaluation in Design Science Research' (FEDS) of [22] with an illustrative scenario [23] is used to. Finally, the *diffusion* of evaluated results is conducted by the paper itself. Section V concludes the paper with a summary and discussion of findings as well as an outlook on further research steps for the next iteration of the frame.

II. Cloud Logistics

A clear context for the design of the CLSB is necessary, i.e. a distinct definition of cloud logistics (CL). As described, CL is a theoretical idea for a new paradigm of logistics. Hence, the currently available literature is searched, analyzed and synthesized. CL is conceptualized, a definition and a conceptual framework is given.

Table I: Amount of papers found and included with exact phrase 'cloud logstics' in title (per database and year).

databases	result	included	2010	2011	2012	2013	2014	2015	2016
google scholar www.scholar.google.com	59	9	1	-	-	-	5	2	1
Springerlink link.springer.com	19	2	-	-	1	1	-	-	-
Science Direct www.sciencedirect.com	6	1	-	-	-	1	-	-	-
IEEE Xplore ieeexplore.ieee.org	6	3	-	-	2	-	1	1	-
Web of Science apps.webofknowledge.com	1	0	-	-	-	-	-	-	-
Emerald Insight www.emeraldinsight.com	0	0	-	-	-	-	-	-	-
ACM dl.acm.org/	0	0	-	-	-	-	-	-	-
Foward and Backward	2	2	1	1	-	-	-	-	-
Total	93	15	2	1	3	2	6	3	1

A. Systematic Literature Review

In a very first step, google scholar presented an amount of 27,500 results searching for 'cloud logistics'. In order to achieve a reasonable quantity, we expect literature dealing meaningfully with it to use the term in the title of the publication as this is a very young field. Next to google scholar further databases were searched for the term 'cloud logistics' in title, which lead to a reasonable amount of papers as shown in Table I (access date: 19^{th} May 2016). Duplicates are excluded and removed (13 paper). Further exclusion criteria are either no recognition of CL as a new paradigm in logistics and/or no accessibility. Most of the excluded paper dealt with the implementation of CC in the logistics domain (without virtualization of physical resources), or e.g. regarded CL as the allocation and management of CC resources on server farms, see [39]. In total, 13 papers form the body of seminal work. Through forward and backward search another 2 paper were found to be relevant for the topic of CL. The concepts of CL in the related literature are discussed and presented.

The conceptualization of topic emerged into the fields of

Table II: Conceptualization of 'cloud logistics' and the characteristics of the included paper.

		layer			virtualization			encapsulation			
publication	defintion	number	Iaas/PaaS/SaaS	physical/virtual/service	semantic-oriented	object-oriented	categorization concepts	service model	(data) interfaces	XML-based description	building blocks
[24]	-	3	x	-	x	-	-	-	x	x	x
[25]	-	6	-	x	-	-	-	-	-	-	-
[26]	-	3	x	-	-	-	-	x	x	x	x
[27]	[24]	3	-	x	x	-	x	-	-	x	-
[28]	[24]	-	-	-	-	-	-	-	-	-	-
[29]	[24]	-	-	-	-	-	-	-	-	-	-
[30]	-	4	-	x	-	-	x	-	-	-	-
[31]	[27]	-	-	-	-	-	-	-	-	-	-
[32]	-	3	-	x	-	x	-	-	x	x	x
[33]	-	3	-	x	x	x	x	-	-	-	-
[34]	[24]	3	-	x	-	-	-	-	-	-	-
[35]	[24]	-	-	-	-	-	-	-	-	-	-
[36]	[27]	3	-	-	-	-	-	x	-	-	-
[37]	-	4	x	-	x	-	-	-	-	-	-
[38]	x	4	x	x	-	-	x	x	x	x	-

definition of CL, layers, virtualization and encapsulation, see Table II. It is evident that there exists no proper *definition* of the term 'cloud logistics' covering its entire and genuine characteristics. All papers eventually root their description of CL on Holtkamp et al. [24] that do not give a definition of CL but rather describe the general idea of adopting cloud principles to the logistics domain, like the other publication created by the Fraunhofer Institutes, i.e. [32]. Leukel et al. [38] establish the term 'supply chain as a service' (SCaaS) and define the terms cloud, supply chain system, (composite) supply chain service and classification scheme. SCaaS is added as another layer to the standard layers of CC on top of SaaS. Summarizing, a definition of CL is required.

Concerning the regarded *layers* of CL two general perspectives exist, which are not mutually exclusive. On the one hand, there is the 'classic' view adapted from CC with the layers of IaaS/PaaS/SaaS that could be extended with a layer on domain-specific logistics services (i.e. Business Process-aaS [26], Process-aaS [37], SCaaS [38]). This view comes with difficulties, as computational resources are getting less physical from IaaS to SaaS but the domain specific layer on top again builds on other physical resources. On the other hand, the majority of publications regard CL with the layers of (1) physical resources that are (2) virtualized into logical resources that afterward are (3) encapsulated into services. Goal is the accessibility and orchestration of physical resources through service interfaces. Additions to those 3 basic layers are conceptually not necessary for the essence of CL paradigm (like extra middleware layer for virtualization and application interface layer of [25] or operation mode layer (public/private/hybrid cloud mode) and user role centered layer of [30]).

The *virtualization* concepts' objective is to establish the connection from physical resources to logical resources and thus, the synchronization between real world and IT-systems. While on the one hand, a business ontology [24] or semantic data mediators [37] are just mentioned, on the other hand ontologies based on resource classification [27] and conceptualization of physical resources [33] are presented. However, the both ontologies differ a lot and do not seem to rely on literature nor on proper ontology engineering. The object-oriented concept of [32] focuses on the essential objects of logistics. They aim at abstracting real-world objects (goods, handling units, transportation vehicles, facilities and documents (e.g. orders, invoices)) by business objects (BO) in order to synchronize physical and virtualized resources. [33] apply an object-oriented approach in order to achieve the unified description of cloud logistics physical resources. A useful categorization concept supports building up a catalog in order to increase the ease of use for a logistics planner or logistics integrator (retrieving services in order to compose them to complex services in order to meet its customers' demand) as well as the ease of use for the LSP (subscription to provider list of existing services in the catalog). [27] distinguish between different types of resources: equipment, human, service, information and financial. [30] present a classification of basic services (transport, warehousing and transshipment) and value-added services. [33] accomplish resource categorization by integrating a taxonomy that is not further detailed. The categorization of [38] is based on the Supply-Chain Operations Reference Model (SCOR) [40] but already in their evaluation example they admit that SCOR is not able to model detailed logistics processes (e.g. ground handling operations at airports). Organization of the content of the services is an important issue in order to grant ease of use. Facilitated virtualization, categorization, finding, and composition of the resources are important requirements for cloud logistics. An ontology should contain information and knowledge about logistics objects (like the BOs of [32]) and logistics resources as well. This comprises also a categorization concepts for enhanced ease-of-use. The concept of the logistics service map [13] also emphasizes the importance of the categorization of logistics services and their resources. It comprises a catalog and a construction kit of modular logistics services in order to engineer and manage logistics services easily.

The presented *encapsulation* of CL are manifold. The hierarchical structure of classic service models (I/P/SaaS) is broken up by Papazoglou [26] in order to modularize and enable free combinations of e.g. SaaS from one provider on a PaaS from another provider run on the physical IaaS from another third provider. This is pointed out as an important requirement for effective implementation of BPaaS. This model comprises functional characteristics, KPIs, resources, policies as well as structured interaction and flow represenation. Leukel et al. [38] build their service model of SCaaS on a flow-oriented perspective of logistics with parameters for products, mode of transport, source and sink. Further, they define input/output/inner data elements for the services and their interfaces. Weißenberg and Springer [32] distinguish between control, data and material flow in logistics. As basic types they introduce GUIs as interfaces for human resources and APIs for machine resources. Sensors are linked in order to retrieve current state parameters of physical resources. Zhang et al. [36] emphasize the combined characteristics of logistics of physical and non-physical objects and thus, argue for a product service system view on logistics. (Logistics) services are encapsulated and accessible via XML-based description and interface. Different purpose-specific languages are described in detail by [26], [32], whereas the other authors only mention their existence. Commonly, an easy-to-understand language for end users is conceptualized, i.e. Blueprint Request Language (BRL) [26] and domain-specific language of industry [32]. Further, a common exchange language of the involved IT-systems is described, i.e. XML-based communication via bus or process engine [32] or more detailed blueprint languages (BxL) of [26] for description (BDL), constraints (BCL) and manipulation (BML). Interestingly, the metaphor of combinable 'lego bricks' for services is explicitly used by [26], [32] and implicated by emphasizing the need for standardized building blocks by [24] in order to enable the idea of CL. This idea avoids pairwise adapters (between LSP and/or their IT-Systems) and data mappings [32]. Further, the creation of newly available services in a logistics network is drastically facilitated. On the one hand, Papazoglou's cloud blueprints [26] aim at creating building blocks for cloud services. On the other hand, [32] aim to abstract real-world objects (goods, handling units, transportation vehicles, facilities and documents (e.g. orders, invoices)) by business objects (BO) in order to synchronize physical and virtualized resources. Hence, the BOs only take the first step of resource virtualization but logistics services are not encapsulated. BOs abstract the logistics objects but not the logistics services whereas the created cloud blueprints are not focusing on logistics.

Summarizing, the idea of *Lego Bricks of Logistics* emerges as pre-built, pre-configured and pre-optimized building blocks focusing on reusable modular capabilities in the logistics domain. Hence, they are filling the gap between cloud blueprints for CC services of [26] and BO of [32]. Main shortcoming of [32] is the need of code generation by domain experts when they want to offer and provide their services via the described 'logistics mall'. The current goal is to create blueprints of logistics services in a language (or graphical notation) that a logistics domain expert could easily understand in order to use them to built collaborative logistics services. Retrieval and access to descriptions must be easy. Existing technical service specifications (e.g. service operations, their input/output parameters and the data types) are to be pre-linked with the business level. This kind of strategy is described in the concept of *look-ahead* [41]. Main input for the lego bricks should be the flows and transformations of logistics domain as the essence of every logistics service.

B. Definition of cloud logistics

As it stems from CC, the definition of CL is based on the CC-defintion of [8] which should be taken into account in order to get the whole picture of CL:

Cloud Logistics is a model, based on and inspired by the paradigm of cloud computing, for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable and virtualized logistics resources (e.g. means of transportation from different modes of transport, warehouses, domain-specific knowledge, logistics applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of the five *essential characteristics* of cloud computing (on-demand self-service, broad network access, resource pooling, rapid elasticity, measured service) but is adjusted in consequence of logistics' more physical character. This comprises: a location dependency of services, the need of knowledge about that current location as well as a lower elasticity due to slower allocation of physical resource. The domain-specific layer *Logistics as a Service (LaaS)* is added to the CC service models. The capability provided to the consumer is to provision transport, storage, handling, knowledge and other fundamental logistics resources where the consumer is able to ship and convey and transform logistics entities, which can be of physical or non-physical character. The logistics resources are purchasable through interfaces combining GUI and/or API. The consumer does not manage or control the underlying logistics infrastructure but has control over the source and sink location and the transformation of the entities shipped as well as control over the configuration settings for the transformation-enabling environment. The *deployment mode* of LaaS results in different business models of logistics service provider (LSP): public cloud (for networks), private cloud (for big LSP with a comprehensive service portfolio) and hybrid (for a participation of big LSP in networks or as the basis of the business model for big LSP to become a Lead Logistics Provider (LLP)).

C. Cloud Logistics Framework

Is CL just old wine in new skins? Of course outsourcing and insourcing of capabilities, processes and resources is nothing new to logistics. However, with the help of CL and the concept of service blueprints, LSP are provided with the possibility to collaborate digital and more flexible within a network. This is possible even without good mutual internal IT systems when the approach is provided by a logistics integrator. CL is not only the application of CC in the

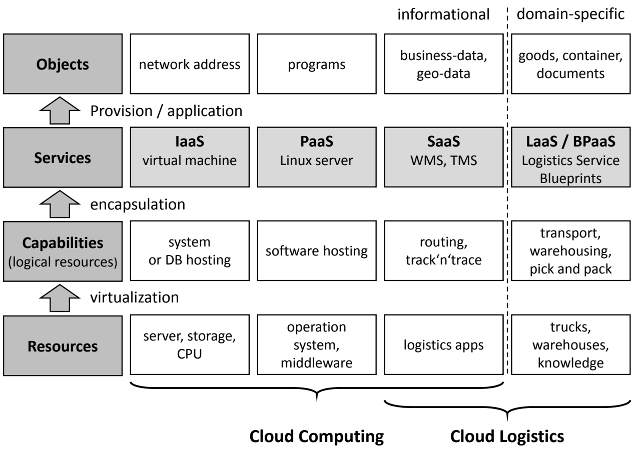

Figure 2: Framework of Cloud Logistics, adapted and extended from Leukel and Scheuermann [42]. Examples are given by small printed text.

logistics domain, but rather the adaption of its principles to the domain-specific (physical) logistics services in order to increase flexibility and collaboration. Furthermore, it helps especially small LSP to take first steps towards digitalization. By extending the existing definition of CC for CL purpose, the definition of CL is formed and builds up the basis of the CL framework presented in Fig. 2 that combines both layer perspectives. The *virtualization* of computing resources is adapted to (mostly physical) logistics resources. By *encapsulating* them, logistics services are shaped, that can be freely combined. Foundation for such a flexible modular collaboration is the design of Logistics Lego Bricks, or the CLSB, respectively, that describe the essential flows and transformations of the logistics domain in order to design compatible virtualized resources from different providers. Objective of services is always the transformation or manipulation of certain objects. Following [36] an integrated view is supported by following a product service system approach for engineering cloud logistics service blueprints, i.e. service blueprinting. Those service blueprints for a cloud-inspired approach and environment are engineered in the next section.

III. Designing a Cloud Logistics Service Blueprint

The above described idea of cloud oriented service blueprints bears potential for other domains as well. Hence, the method of their design will be firstly developed without domain-specific aspects of logistics. Afterward, the method is applied to the logistics domain.

A. Involved Engineering Methods

1) Extended Service Blueprinting: The method of service blueprinting [43], especially the modified version extended service blueprinting by [19], offers suitable aspects to describe services that are based on both business services and electronic services, see Fig. 3. The essential aspects of services [7], i.e. interaction between consumer and provider, value creation, input and output (physical or non-physical, e.g. information, skills, knowledge or costumer requirements) can be modeled with the help of extended service blueprinting. Hara et al. [19] distinguish between a *behavior blueprint* that represents the 'hardware' and their related software involved in a service (= electronic services) as well as an *activity blueprint* that represents the 'humanware' and their related supporting software (= business services). General depiction method is the business process management notation (BPMN) in order to ensure a common and easily understandable communication standard. Services in general are seen as a set of functions that have a possible value for customers in terms of changing one or more receiver state parameters (RSP) [44], [45]. Those RSP could be structured down to the lowest level where they represent basic functions and are mapped afterward to specific process steps of services in order to highlight their importance in the context of interaction with the customer. The change of the RSP is the goal of business activities and thus they form the customers' requirements. Further, two important lines are introduced: the line of interaction (separating service consumers and service providers) and the line of visibility (separating 'onstage (visible)' and 'backstage (invisible)' of activities performed by the provider). An inter-relation between the activity blueprint (humanware + related software) and the behavior blueprint (hardware + related software) is obligatory for the extended service blueprinting. A further connection is established between the functions of the RSP (customer requirements) and the appropriate process steps.

2) Domain Engineering: Domain Engineering [20] is used to find common and varying points of a domain in order to determine configurable requirements. The created domain model serves as a generic architecture for a con-

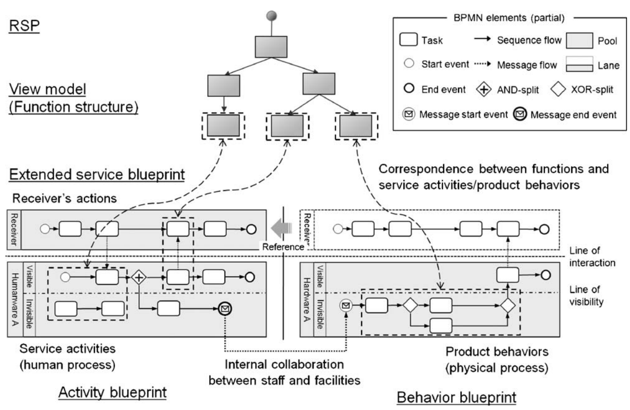

Figure 3: Notation of the extended service blueprint taken from Hara et al. [19].

figurable and standardized solution for a family of systems. An advantage is the creative character. Not only existing systems of a domain are to be collected and formalized, but also additional domain knowledge can be added in order to improve the result. With a domain categorization similarities and differences are the core of re-configurability. Goal is to enable functional and architectural reuse of software.

As the automated exchange of software and interaction with logistics systems is the goal of cloud oriented service blueprints, domain engineering appears to be suitable to be integrated into the whole design method.

3) General Morphological Analysis: The General Morphological Analysis (GMA) [21] can analyze and formalize organizational and stakeholder structures as well as planning issues and present them in a morphological field format. The objective is to identify all dimensions of a problem as well as the possible spectrum of values within the dimensions. The method is suitable to structure and investigate the total set of relationships of mutli-dimensional, non-quantifiable problem complexes.

B. Method for Designing Cloud Oriented Service Blueprints

Services in general are relying mainly on a specific input of physical and/or non-physical elements that are changed in a certain kind of way during the service provision. Non-physical elements are obligatory as e.g. information of the customer sets the requirements and objectives of service provision. Further, this implies an interaction between consumer and provider and a certain value creation for the customer, which means a change of certain parameters is the customer's motivation and defines the output of a service [7]. Alternatively speaking, a service can be characterized by (1) a *flow of entities* (physical or non-physical) and (2) a certain *transformation* of those entities. Hence, a Cloud Oriented Service Blueprint has to describe the essential flows and transformations of the target domain.

Having this and the aforementioned methods in mind, the resulting objective is to design, a specific domain's essential flows and transformations and the human and machine related interfaces. The objective of the service is the transformation of customer's RSP. Hence, the idea arises that the typical RSP of a specific domain is always built upon a certain set of possible domain-specific transformations. The possible values of the flow and transformation dimensions can be figured out with the GMA. Consequently, those common points can be pre-configured in a cloud Oriented Service Blueprint with interfaces for input and output data elements and an inner data element [38] and an interface to invoke further (sub-)services. Inspired by the blueprint of [26] KPIs, resource utilization and policies (Figure 4) and the according languages (Figure 5) are taken into account. The *look-ahead* strategy by Bauer et al. [41] for improving quality and cost-effectiveness of process-oriented, service-driven applications focuses on the description of reusable services with graphical notations or with a language that is understandable to a domain expert with just low or even without IT-Skills at all. This conforms with the ideas of Papazoglou's BRL [26] and Weißenberg et al.'s domain-specific language of industry [32]. Additionally, the orchestration and automation in the background requires the description to be understandable by machines as well, e.g. BxL blueprint languages of [26].

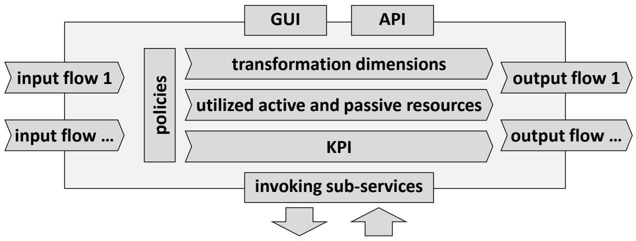

Figure 4: The Cloud Oriented Service Blueprint contains flow-related interfaces, transformations and interfaces for invoking other (sub-)services, as well as resource utilization, policies and KPI.

Language	Resources	Target
Convenient Blueprint Request Language	request and discovery	user and developer centric
Blueprint Defintion Language	utilization	transformation dimensions, active and passive resources, KPI, interfaces
Blueprint Compliance Language		SLA, privacy and security, law and customer constraints
Blueprint Manipulation Language		algebraic operators, e.g. match, merch, compose, delete, etc.

Figure 5: The blueprint framework and its blueprint languages.

This pre-configured blueprint represents a process-oriented service perspective like the extended service blueprint of Hara et al. [19] that is based on the BPMN language. Transformations always aim at specific values of a domain or domain-specific RSP, respectively. Hence, it is only useful to focus on the transformations of dimensions, which are transformable by the services of a specific domain. With this common understanding, a high flexibility, simple communication and ease of use in service networks can be achieved. The question *What should be done 'right' in order to provide the service in a customer satisfying way?* can be used as a guidance (e.g. 'the domain's objective is to transform the right *entity* from the right *input* into the right *output* with the right *costs* under the right *conditions*' etc.). The resulting method involves the following steps:

1) develop a convenient *request language* by finding representational questions a service costumer could have concerning service objectives (brainstorming with domain experts)

2) develop the *description language* with conceptually configured and domain-specific common points:
   a) essential transformation dimensions for both hardware and humanware (What has to be done *right*?)
   b) essential flows for the interfaces (input, output, request of sub-services (What are the *right* entities?)
3) extend the *description language* with conceptually configured and domain-specific varying points by identifying the morphological field that can be extended later on:
   a) possible 'active' domain-specific resources that enable transformations (e.g. staff, machines, infrastructures)
   b) possible 'passive' domain-specific resources that enable flows (e.g. business objects: container, documents)
   c) domain-specific SLA
4) develop the *compliance language* with conceptually configured privacy, security, mandatory and non-mandatory constraints
5) develop the *manipulation language* for opreations with other blueprints

C. Cloud Logistics Service Blueprint

The method above is applied to the logistics domain. As [36] emphasize logistics' characteristics of physical and non-physical objects and thus, argue for a product service system view on logistics, the method based on extended service blueprinting is suitable. When creating a basic cloud Logistics Service Blueprint (CLSB), which is based on the extended service blueprinting, the concept shown in Figure 3 has to be encapsulated and logistics characteristics have to be taken into account. From the basic logistics lego brick (the CLSB), specific logistics services can be derived that incorporate distinct logistics resources in order to fulfill logistics functions, i.e. transformations. Because of the services with common interfaces, those logistics functions can be combined and thus cloud logistics is enabled. The results of the several steps are shown in a conceptual way. Implementation is to be done in an XML-based language.

(1) The request should enable consumers to discover and request appropriate resource (e.g., 'I need this many trucks with a pallet capacity of x', or 'I need cooled storage capacity for x pallets') and higher-level application requests (e.g., 'I need enough capacity to perform this specific service') over standardized blueprint images that are stored in the logistics service map [13] that act like a catalog of cloud services and providers. Hence, the request language should be able to express kind and number of the resources, transformations based on the flows.

(2) The description of the logistics services should comprise all essential *transformations* of the logistics domain. Mentzer et al. [46] describe the 7R as the common points of a successful logistics that targets to deliver:

1) the right product
2) to the right location
3) in the right time
4) in the right quality
5) in the right quantity
6) for the right price
7) with the right information

Since these are target to be delivered by logistics, logistics must be able to manipulate or transform them, respectively. Thus they form the core transformation dimensions. Essential *flows* of logistics are the flow of information and the flow of goods [47]. [32] additionally take the flow of control into account for their approach of logistics BO. Sometimes the financial flow is also mentioned as essential for logistics but can be left out. On the one hand it is not in the main focus of logistics, and on the other hand it is implicitely contained as it can be regarded as a kind of informational flow in the context of online banking (even though, there may be higher formal and security requirements). Cloud logistics is information intensive and comprises also information-centric (sub-)services (e.g. customs clearance, identification or track and trace). Hence, the flow of physical goods is not always obligatory for every service but overall objective of logistics is still the re-allocation of physical goods. Summarizing, it has to be mentioned that the CLSB are not re-allocating the goods themselves but information about the physical re-allocation and transformation has to be passed on in order to trigger human or machines to fulfill the distinct transformation via an API or GUI.

(3) The possible resources of the logistics domain that are used in order to conduct the transformation are manifold. As they form the varying points, it is appropriate to just present a selection, that has to be customized (extended or reduced) according to the use case. *Active resources* of logistics are (with example transformations in parenthesis) e.g. trucks (location), warehouses (time, quality), picking systems (product, quantity), conveyors (location), sorter (product, quantity), warehouse management systems (WMS) and Transport Management Systems (TMS) (information), etc. Hence, those resources are able to actively transform the dimensions mentioned in the point before. The *passive resources* of logistics systems are either of physical character (according to the physical flow, e.g. packing, pallet, trailer, container) or of non-physical character (according to the informational flow, e.g. freight documents, pick lists, warehousing contract). The domain specific *SLA* are also part of the varying point and they are case-depended and determined in individual logistics contracts. A selection comprises lead time, delivery rate, reliability, picking accuracy.

(4) Privacy concerns in logistics are a further research topic for themselves, e.g. see [48], [49]. Mandatory con-

straints comprise legal regulation [30] on e.g. securing of cargo on means of transport [50], permission to handle dangerous goods [51], permission to handle transport entities that are alive. Non-mandatory constraints could be preferences or requirements of the customer, e.g. cold chain, CO_2 reduced logistics, express (fastest lead time possible).

(5) As logistics is characterized by specialization and outsourcing, the typical manipulation operators are needed, e.g. match, merch, compose, delete, extract, disjoint, etc.

The outlined results are summarized in Figure 6. With the final output of information, parameters of service quality as well as the control flow, the next logistics module (if existant) can be forwarded. The three mentioned flows are also involved in requesting and invoking further sub-services. Following the ideas of [24], [27] an ontology appears to be suitable to model and describe the particular varying points (active and passive resources) of an logistics network. It should be based on the morphological field but can be extended or reduced if necessary. The capabilities of services that are created on the base of the CLSB could be interpreted as a resource of the logistics network as well, hence it appears usefull to collect those capabilities in an ontology as well. As proper ontology engineering is a challenging task, this topic is beyond the scope of the current paper. With the CLSB flexibility can be improved as well as simple communication and ease of use.

IV. Evaluation of the Logistics Service Blueprint

For the evaluation the 'Framework for Evaluation in Design Science Research' (FEDS) of [22] is taken into account and a *quick & simple* strategy is chosen, as the

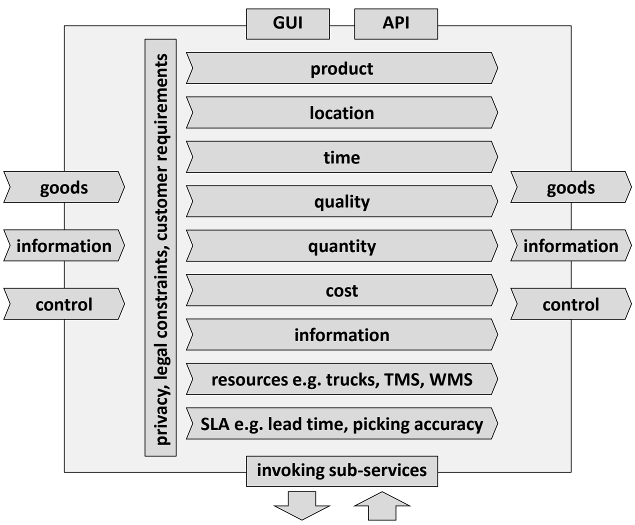

Figure 6: The cloud logistics service blueprint (CLSB) is developed by application of the cloud oriented service blueprint to the logistics domain.

designed artifact is of small and simple construction, with low social and technical risk and uncertainty. An illustrative scenario [23] is chosen to evaluate the developed artifact of CLSB. The evaluation is summative (judge the extent that the outcomes match expectations) and located in the middle between artificial and naturalistic: example processes of the logistics domain from two real internationally operating LSP are anonymized (due to privacy reasons) and they are modeled with the help of the CLSB proofing the feasibility. Goal is to create logistics services that could be easily connected even though they are offered by different LSP. This represents a realistic scenario in a logistics network characterized by specialization and division of labor. Such a network could be managed (planning, controlling, monitoring) by a central logistics integrator.

LSP 1 offers the service 'off-loading of long-distance truck transport' within the network. This comprises all physical entity movements from the truck and follows the steps of (1) getting freight documents from the driver, (2) identification, scanning and off-loading of package, (3) bringing package to pallet space and (4) scanning and forwarding protocol. The input flows are informational (freight document: goods identification, quantity, shipper, consignee) and physical (pallets containing goods). The control flow is then later on added, when the logistics service is composed with other services. The trigger signal would be the arriving of the truck at the warehouse. The transformations aim at the dimensions of location (truck to pallet space), time (the process takes a certain amount of time), costs (occuring for the provision of the service), information (state of the BO pallet containing a certain good changes from in transfer to in warehouse, and the location information is changed as well). The necessary resources for this comprise staff, forklifts, scanners, WMS (active), and pallet, freight documents (passive). Important KPI and SLA comprise the time consumed, the accuracy of identification of goods, identification of pallet space and the matching of the latter two. For the forwarding of the protocol that contains the transformations done, electronic web services could be used for information transmission to the logistics integrator.

LSP 2 offers the service 'order picking air' within the network. This comprises the steps of (1) pallet picking, (2) scanning, (3) transportation to air packing station, (4) loading aircraft container, (5) scanning, (6) transferring aircraft container to outbound, (7) scanning. The input flows are informational (electronic data on handheld: flight number, start time and end time (critical due to flight schedule), aircraft type, terminal, position (aircraft parking space), pallet space) and physical (aircraft containers carrying goods). The control flow is then later on added, the trigger signal would be of timely manner according to flight schedule. The transformations aim at the dimensions of product (the right products have to be collected), location (goods from warehouse to packing station to outbound), time, quantity (certain amount is picked), cost, information (state of the BO pallet from warehouse to packing, state of the BO goods from pallet to aircraft container, state of the BO aircraft container from packing to outbound). The necessary resources for this comprise staff, forklift, scanner, WMS, tractor unit (active), and pallet, loading document, aircraft container, trolley (passive). Important KPI and SLA comprise the time consumed, picking accuracy, throughput. Electronic services are invoked to transfer data, identification of required aircraft container type according to aircraft type.

The potential for *cloud logistics* comprises the following aspects: (1) those two example services can be added to the networks portfolio. Hence, both can be composed in order to form the complex service of transshipment between road and air transport when the pallet spaces of the both processes are merged. (2) Due to virtualization, it is possible to e.g. add another provider (LSP X) to the list of LSP able to fulfill the off-loading service. Now as more LSP offer their resources (staff, forklifts) a bottleneck in the inbound area could be dispatched by requesting resources from LSP X. A higher specialization is imaginable, e.g. LSP 1 focuses on standard goods, whereas LSP X could handle dangerous goods or offer its resources flexibly to either off-loading or the picking for the outbound for a higher price in order to break an upcoming bottleneck. (3) The resource list (e.g. ontology) contains forklifts at the transshipment site that could be provided by different LSP.

Summarizing with the connection of the both services and the utilization of the virtualized resources cloud logistics is enabled. To the customer of the central logistics integrator just the transshipment is offered as a service. The operations, resources and their providers remain transparent to the customer. The basic characteristics of the cloud paradigm are transferred to the logistics domain. Flexibility of resource usage is increased, communication can be simplified and the ease of use in planning is increased due to the logistics lego bricks, aka CLSB.

V. Conclusion

The paper systematically reviewed the existing literature and research gaps of 'cloud logistics'. The topic was conceptualized in order to develop a definition of the term (SQ_1 is answered) and framework in order to separate it from and simultaneously integrate it with cloud computing. The most promising field of research is the identification and conceptualization of standardized modules or 'lego bricks' of logistics in order to enable cloud logistics. Existing ideas are taken from the state of the art and integrated with the help of several service engineering methods (SQ_2 is answered) in order to develop Cloud Oriented Service Blueprints. Those Cloud Oriented Service Blueprints are applied to the logistics domain in order to create Cloud Logistics Service Blueprints (CLSB) as standardized modules, shaping the foundation of cloud logistics (SQ_3 is answered). Two services from process descriptions of internationally operating LSP are taken into account to evaluate the suitability of the CLSB with a illustrative scenario in a quick & simple strategy. The outcome - the CLSB - matches expectation of enabling CL in terms of virtualized resources encapsulated in services.

The systematic literature review reveals some threats to validity: completeness (selection of database, technical limitations of search functions) and reliability (bias is reduced due to literature analysis done by all authors, but could not be fully excluded).

Implications are rather existent for researchers by adding to current literature on CL and, as an outllok, opening research questions towards comprehensive virtualization of the varying points (resources). This is complicated, as logistics network are of dynamic character. Hence, ontology engineering (from literature and and practice) to offer a first starting point to LSP in order to use CL is one of the next steps.

Acknowledgment

The work presented in this paper was funded by the German Federal Ministry of Education and Research within the project *Logistik Service Engineering und Management* (LSEM). More information can be found under the reference BMBF 03IPT504X and on the website www.lsem.de.

References

[1] J. Langley and M. Long, "2016 third-party logistics study: The state of logistics outsourcing: Results and findings of the 20th annual study," vol. 20, 2016.

[2] R. Wilding and R. Juriado, "Customer perceptions on logistics outsourcing in the european consumer goods industry," *International Journal of Physical Distribution & Logistics Management*, vol. 34, no. 8, pp. 628–644, 2004.

[3] A. Aguezzoul, "Third-party logistics selection problem: A literature review on criteria and methods," *Omega*, vol. 49, pp. 69–78, 2014.

[4] T. Solakivi, J. Töyli, and L. Ojala, "Logistics outsourcing, its motives and the level of logistics costs in manufacturing and trading companies operating in finland," *Production Planning & Control*, vol. 24, no. 4-5, pp. 388–398, 2013.

[5] S. Kumar, V. Dakshinamoorthy, and M. S. Krishnan, "Does soa improve the supply chain? an empirical analysis of the impact of soa adoption on electronic supply chain performance," in *40th Annual Hawaii International Conference on System Sciences (HICSS'07)*, 2007, 171b.

[6] A. Arsanjani, G. Booch, T. Boubez, P. Brown, D. Chappell, J. deVadoss, T. Erl, N. Josuttis, D. Krafzig, M. Little, B. Loesgen, A. T. Manes, J. McKendrick, S. Ross-Talbot, S. Tilkov, C. Utschig-Utschig, and H. Wilhelmsen. (2009). Soa manifesto, [Online]. Available: http://www.soa-manifesto.org/SOA_Manifesto.pdf.

[7] T. Erl, *SOA: Principles of service design*, 5. print, ser. The Prentice Hall service-oriented computing series from Thomas Erl. Upper Saddle River, NJ [u.a.]: Prentice Hall, 2009, ISBN: 9780132344821.

[8] P. Mell and T. Grance, "The nist definition of cloud computing," *Computer Security Division, Information Technology Laboratory, National Institute of Standards and Technology Gaithersburg*, 2011.

[9] L. M. Vaquero, L. Rodero-Merino, J. Caceres, and M. Lindner, "A break in the clouds," *ACM SIGCOMM Computer Communication Review*, vol. 39, no. 1, p. 50, 2008.

[10] W. Delfmann and F. Jaekel, *The cloud - logistics for the future? discussionpaper*, German Logistics Association - BVL International, Ed., 2012.

[11] P. Gupta, A. Seetharaman, and J. R. Raj, "The usage and adoption of cloud computing by small and medium businesses," *International Journal of Information Management*, vol. 33, no. 5, pp. 861–874, 2013.

[12] U. Arnold, J. Oberlander, and B. Schwarzbach, "Logical—development of cloud computing platforms and tools for logistics hubs and communities," in *Computer Science and Information Systems (FedCSIS), 2012 Federated Conference on*, 2012, pp. 1083–1090.

[13] M. Glöckner and A. Ludwig, "Towards a logistics service map: Support for logistics service engineering and management," in *Pioneering solutions in supply chain performance management: Proceedings of the Hamburg International Conference of Logistics (HICL) 2013*, ser. Supply chain, logistics and operations management, T. Blecker, W. Kersten, and C. Ringle, Eds., vol. 17, Eul, 2013, pp. 309–324, ISBN: 978-3844102673.

[14] A. Hevner, S. March, J. Park, and S. Ram, "Design science in information systems research," *MIS Quarterly*, vol. 28, no. 1, pp. 75–105, 2004.

[15] H. Österle, J. Becker, U. Frank, T. Hess, D. Karagiannis, H. Krcmar, P. Loos, P. Mertens, A. Oberweis, and E. J. Sinz, "Memorandum on design-oriented information systems research," *European Journal of Information Systems*, vol. 20, no. 1, pp. 7–10, 2010.

[16] J. Vom Brocke, A. Simons, K. Riemer, B. Niehaves, R. Plattfaut, and A. Cleven, "Standing on the shoulders of giants: Challenges and recommendations of literature search in information systems research," *Communications of the Association for Information Systems*, vol. 37, no. 9, pp. 205–224, 2015.

[17] B. Kitchenham and S. Charters, "Guidelines for performing systematic literature reviews in software engineering: Technical report, ver. 2.3 ebse technical report. ebse," PhD thesis, Keele University, UK and Lincoln University, NZ, 2007.

[18] J. Webster and R. T. Watson, "Analyzing the past to prepare for the future: Writing a literature review," *MIS Quarterly*, vol. Vol. 26, no. No. 2, pp. 13–23, 2002.

[19] T. Hara, T. Arai, Y. Shimomura, and T. Sakao, "Service cad system to integrate product and human activity for total value," *CIRP Journal of Manufacturing Science and Technology*, vol. 1, no. 4, pp. 262–271, 2009.

[20] K. Czarnecki and U. Eisenecker, *Generative programming: Methods, tools, and applications*. Boston: Addison Wesley, 2000, ISBN: 0-201-30977-7.

[21] T. Ritchey. (2013). General morphological analysis - a general method for non-quantified modelling, [Online]. Available: http://www.swemorph.com/pdf/gma.pdf.

[22] J. Venable, J. Pries-Heje, and R. Baskerville, "Feds: A framework for evaluation in design science research," *European Journal of Information Systems*, 2014.

[23] K. Peffers, M. Rothenberger, T. Tuunanen, and R. Vaezi, "Design science research evaluation," in *Design science research in information systems*, ser. Lecture Notes in Computer Science, K. Peffers, Ed., vol. 7286, Springer, 2012, pp. 398–410, ISBN: 978-3-642-29862-2.

[24] B. Holtkamp, S. Steinbuss, H. Gsell, T. Loeffeler, and U. Springer, "Towards a logistics cloud," in *2010 Sixth International Conference on Semantics Knowledge and Grid (SKG)*, 2010, pp. 305–308.

[25] X. Wang, W. Li, Y. Zhong, and W. Zhao, "Research on cloud logistics-based one-stop service platform for logistics center," in *2012 IEEE 16th International Conference on Computer Supported Cooperative Work in Design (CSCWD)*, 2012, pp. 558–563.

[26] M. P. Papazoglou, "Cloud blueprints for integrating and managing cloud federations," in *Software service and application engineering*, ser. Festschrift, M. Heisel, Ed., vol. 7365, Springer, 2012, pp. 102–119, ISBN: 978-3-642-30834-5.

[27] W. Li, Y. Zhong, X. Wang, and Y. Cao, "Resource virtualization and service selection in cloud logistics," *Journal of Network and Computer Applications*, vol. 36, no. 6, pp. 1696–1704, 2013.

[28] J. Wang, X. Zhang, X. Hu, and J. Zhao, "Survey on logistics service mode based on cloud computing," in *LISS 2013*, R. Zhang, Ed., Springer, 2015, pp. 321–327, ISBN: 978-3-642-40660-7.

[29] ——, "Cloud logistics service mode and its several key issues," *Journal of System and Management Sciences*, vol. 4, no. 2, pp. 34–44, 2014.

[30] C. Li, X. Zhang, and L. Li, "Research on comparative analysis of regional logistics information platform operation mode based on cloud computing," *International Journal of Future Generation Communication and Networking*, vol. 7, no. 2, pp. 73–80, 2014.

[31] Á. Bányai *et al.*, "Cloud logistics," *Polish Journal of Management Studies*, vol. 8, no. 1, pp. 11–16, 2014.

[32] N. Weißenberg and U. Springer, "Cloud process modeling for the logistics mall-object-aware bpm for domain experts," *Open Journal of Mobile Computing and Cloud Computing*, vol. 1, no. 2, pp. 31–49, 2014.

[33] Y. Zhong, W. Li, W. Guo, L. Gong, and G. Lodewijks, "A method of modeling and service encapsulation on cloud logistics resources," in *2015 IEEE 19th International Conference on Computer Supported Cooperative Work in Design (CSCWD)*, 2015, pp. 383–388.

[34] S. Zhang and X. Hu, "Game analysis on logistics cloud service discovery and combination," *International Journal of u- and e-Service, Science and Technology*, vol. 8, no. 10, pp. 193–202, 2015.

[35] X. He, J. Jiang, and G. Wei, "The cloud logistics modeling and validation based on pi calculus," in *First International Conference on Information Sciences, Machinery, Materials and Energy*, 2015.

[36] Y. Zhang, S. Liu, Y. Liu, and R. Li, "Smart box-enabled product–service system for cloud logistics," *International Journal of Production Research*, pp. 1–14, 2016.

[37] A. Schuldt, K. Hribernik, J. D. Gehrke, K.-D. Thoben, and O. Herzog, "Cloud computing for autonomous control in logistics," in *GI Jahrestagung (1)*, 2010, pp. 305–310.

[38] J. Leukel, S. Kirn, and T. Schlegel, "Supply chain as a service: A cloud perspective on supply chain systems," *IEEE Systems Journal*, vol. 5, no. 1, pp. 16–27, 2011.

[39] F.-C. Jiang, C.-T. Yang, Y.-H. Chen, W.-T. Huang, and H.-Y. Chao, "Decision support for cloud logistics by optimizing the quantities of standby servers in cloud environment," in *2015 International Conference on Cloud Computing and Big Data (CCBD)*, 2015, pp. 169–172.

[40] Supply Chain Operations Reference Model. (1996). Supply Chain Council, Ed., [Online]. Available: http://www.apics.org/sites/apics-supply-chain-council/frameworks/scor.

[41] T. Bauer, S. Buchwald, and M. Reichert, "Improving the quality and cost-effectiveness of process-oriented, service-driven applications: Techniques for enriching business process models," 2013.

[42] J. Leukel and A. Scheuermann, "Cloud logistics ist mehr als logistiksoftware aus der cloud," *Wirtschaftsinformatik & Management*, vol. 6, no. 1, pp. 38–45, 2014.

[43] L. G. Shostack, "How to design a service," *European Journal of Marketing*, vol. 16, no. 1, pp. 49–63, 1982.

[44] T. Sakao and Y. Shimomura, "Service engineering: A novel engineering discipline for producers to increase value combining service and product," *Journal of Cleaner Production*, vol. 15, no. 6, pp. 590–604, 2007.

[45] T. Arai and Y. Shimomura, "Proposal of service cad system - a tool for service engineering -," *CIRP Annals - Manufacturing Technology*, vol. 53, no. 1, pp. 397–400, 2004.

[46] J. T. Mentzer, D. J. Flint, and J. L. Kent, "Developing a logistics service quality scale," *Journal of Business Logistics*, vol. 20, no. 1, p. 9, 1999.

[47] T. Gudehus and H. Kotzab, *Comprehensive Logistics*. Berlin, Heidelberg: Springer Berlin Heidelberg, 2012, ISBN: 978-3-642-24366-0.

[48] A. Marucheck, N. Greis, C. Mena, and L. Cai, "Product safety and security in the global supply chain: Issues, challenges and research opportunities," *Journal of Operations Management*, vol. 29, no. 7-8, pp. 707–720, 2011.

[49] M. Zhou, R. Zhang, W. Xie, W. Qian, and A. Zhou, "Security and privacy in cloud computing: A survey," in *2010 Sixth International Conference on Semantics Knowledge and Grid (SKG)*, 2010, pp. 105–112.

[50] *Us patent 2,605,064 cargo securing system*, 1952.

[51] *ADR - European Agreement Concerning the International Carriage of Dangerous Goods by Road: Applicable as from 1 January 2013*. New York [etc.]: United Nations, 2012, ISBN: 978-92-1-139143-5.

2.2 Executive Summary

The paper contains the conceptual basis of the *landscape* that facilitates the engineering of cloud logistics service. With the help of a systematic literature review, the field of cloud logistics is analyzed, conceptualized and a *first definition* of the term cloud logistics in scientific literature is given. The conceptual framework of CC is extended towards a *conceptual framework of CL* and the concept of *cloud logistics service blueprints* is developed. The analytical method is a systematic literature review following Vom Brocke, Simons, Niehaves, et al. [2009]. The design approach is based on methods of extended service blueprinting [Hara et al., 2009], domain engineering [Czarnecki and Eisenecker, 2000] and general morphological analysis [Ritchey, 2013]. The evaluation is based on FEDS [Venable et al., 2014] complemented by ideas of Peffers, Rothenberger, et al. [2012]. The paper answers RQ_1 (see Section 1.2) by dividing it into three sub-questions:

- What is the leading definition of cloud logistics?
- What are suitable service engineering methods for creating cloud oriented service blueprints?
- What is an appropriate conceptualization of the logistics domain (description, flows, interfaces, transformations) in order to develop Cloud Logistics Service Blueprints for enabling cloud logistics?

The conceptualization of CL comprises the source of definition, the nature and amount of layers as well as the virtualization and encapsulation concepts. The question of *defining cloud logistics* revealed that almost all papers have based their 'definition' on two papers, whereas one of them has based it on the other one. Further, the one paper everything was based on did not give any particular definition of the term cloud logistics but rather described the conceptual idea behind it. One paper included a definition in terms of pure mathematical concepts of services, resources and relations with a high similarity to operations research. Thus, the research gap of an explicit definition was revealed and closed. The *nature and amount of layers* varied, if existant, between 3 and 6. On the one hand, some publications based the layers on the IaaS - PaaS - SaaS paradigm, whereas others used a distinction between physical - virtual - and service. The latter one is situated closer to the core of the cloud principles with a focus on virtualization and encapsulation of resources. The *virtualization* concepts found are either on a semantic or object-oriented basis or invoke other categorization concepts. Leading literature suggests a semantic approach as a suitable option to bridge the heterogeneity. *Encapsulation* comprises the way how final services are described, and if an explicit service model is described, (data) interfaces are described, an XML-based description is defined or the concept of reusable building blocks is invoked. In Addition to the first definition of cloud logistics, the conceptual framework of cloud computing is extended by a domain-specific dimension and the layers of resources, capabilities and objects in order to describe the field of cloud logistics, see Figure 2.1. Additionally, a first concept of general cloud service blueprints is briefly outlined. With this cloud logistics service blueprints are developed as a conceptual template for the creation of logistics services in cloud logistics.

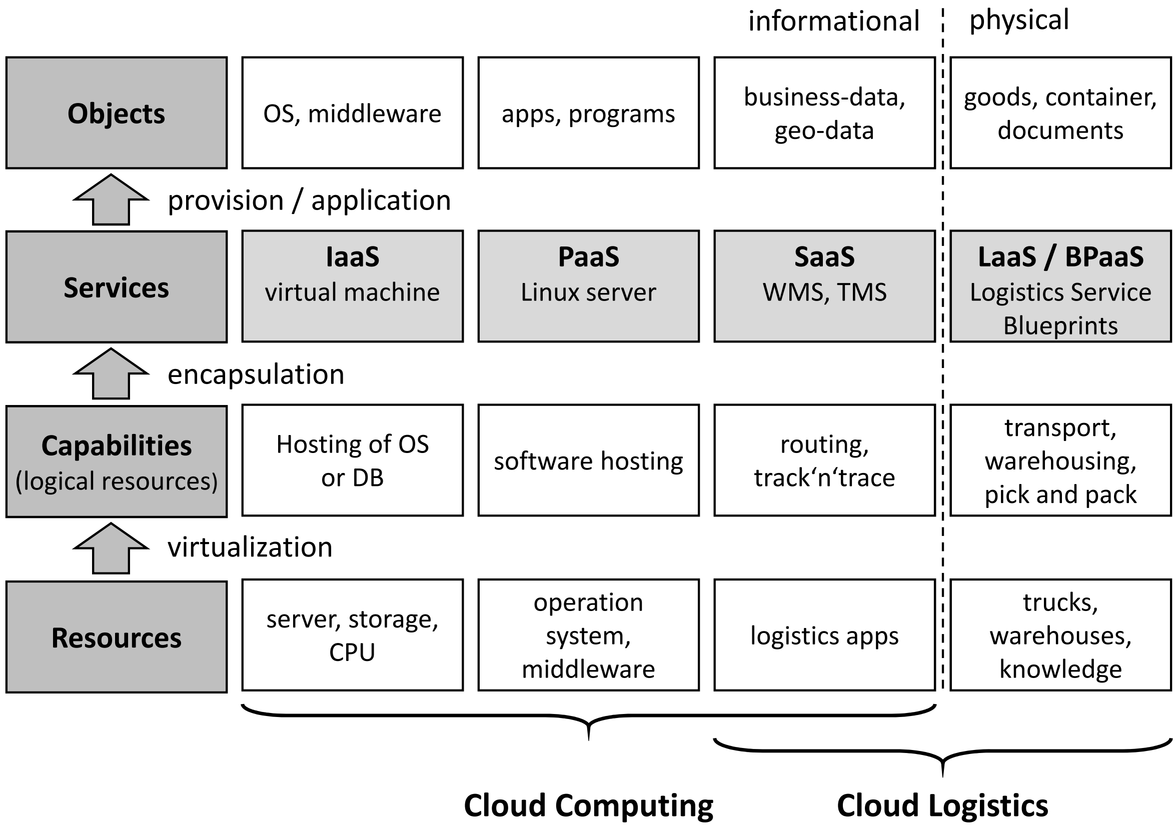

Figure 2.1: The conceptual cloud logistics framework.

In terms of contribution type level (see Table 1.2) and the kind of knowledge contribution (see Table 1.9), the artifacts of the paper can be characterized as follows: The definition of the term *cloud logistics* as well as the conceptual framework are foundational artifacts of a new field of research. Hence, the problem as well as the solution maturity are low in both cases. Accordingly, the knowledge contributions of those artifacts are inventions. The adoption of general service blueprints to the topic of CL constitutes an exaptation. Artifacts in a relatively new field hardly lead to a high contribution type level [Gregor and Hevner, 2013]. Still, those artifacts can be applied to a certain range of problems and thus are located on the second level.

This papers lays the foundation for the engineering of a cloud logistics service description ("service landscape") and is complemented technically by the artifact of paper #2. The results are further used for the service granularity framework (#5), transitively for the prototype (#6), as well as the consolidation and research roadmap (#8).

3 Landscape - Technical

Glöckner, Michael; Ludwig, André (2017): LoSe ODP - An Ontology Design Pattern for Logistics Services. In: Karl Hammar, Pascal Hitzler, Adila Krisnadhi, Agnieszka Lawrynowicz, Andrea Nuzzolese, Monika Solanki (Hg.): Advances in Ontology Design and Patterns. 2017. Amsterdam: IOS Press, Netherlands (Studies on the Semantic Web, 32), S. 309–324. [Glöckner and Ludwig, 2017a]

3.1 "LoSe ODP - An Ontology Design Pattern for Logistics Services"

Table 3.1: Meta data of the publication (Landscape - Technical).

DOI	10.3233/978-1-61499-826-6-131
URL	`http://ontologydesignpatterns.org/wiki/images/f/fb/WOP2016_paper_14.pdf`
Type	Book Chapter
Publication in	Proceedings of the International Semantic Web Conference (ISWC) 2016 - Workshop on Ontology and Semantic Web Patterns (7th edition) - WOP 2016
Editor	Karl Hammar, Pascal Hitzler, Adila Krisnadhi, Agnieszka Lawrynowicz, Andrea Nuzzolese, Monika Solanki
Series Title	Studies on the Semantic Web
ISSN / ISBN	1868-1158 (ISSN), 978-1-61499-825-9 (ISBN)
Publisher	IOS Press
Place of Publication	Kobe, Japan (ISWC 2016); Amsterdam, Netherlands (Book)
Ranking	CORE: A-ranked (conference) VHB: - h-index: -

LoSe ODP - An Ontology Design Pattern for Logistics Services

Michael Glöckner, Leipzig University, Germany

André Ludwig, Kühne Logistics University, Germany

Abstract

Logistics is a service-oriented industry. Trends like outsourcing and concentration on core competencies require logistics service provi-ders to collaborate with each other and compose their services in order to fulfill complex customer demands. The idea of generic logistics service building blocks helps to make composition of logistics services more easy in general. The composition of logistics services from different providers is a challenging task due to the semantic gap of differing wordings, descriptions and IT-systems. With a central ontology design pattern for such logistics service building blocks, the semantic gap can be closed. Data and information (of services) from different providers can be made available, linked and interchanged easily within the network. Virtualized resources and digitalized collaboration are supported and the disruptive paradigm of cloud logistics is enabled.

Keywords

ontology design pattern, logistics, service, composition, cloud logistics

0.1. Introduction

Logistics is a service-oriented industry. The logistics domain is facing the trends of outsourcing and concentration on core competencies [17, 30] as well as digitalization [15]. The concentration on core competencies requires logistics service providers (LSP) to collaborate with each other in order to fulfill complex customer demands. With an increasing digitalization and the adoption of the cloud principles to the logistics domain, the disruptive paradigm of *cloud logistics* emerges [6, 13, 35], i.e. resource virtualization, ad-hoc reconfiguration, inter-connectability via an ontological approach. Taken from cloud computing as well, the idea of reusable cloud blueprints [24] is adapted to the logistics domain in order to create generic building blocks the are interconnectable like *'lego bricks'* [24, 35]. Nevertheless, the composition of logistics services from different providers remains a challenging task due to the semantic gap of differing wordings, descriptions and IT-systems.

Focusing on the essential common characteristics of logistics services and their consolidation within an ontology can help to close the semantic gap. Still, different networks and different industries (e.g. automotive, chemistry) have different logistics requirements. The creation of logistics service building blocks is then dependent on semantic building blocks, so called ontology design patterns (ODP) [27]. Hence, a reusable content ODP (CP) describing logistics services is needed. Such a CP further supports the aspects described in cloud logistics paradigm, i.e. virtualization of resources and their inter-connectability. The research question arises: *How can essential aspects of logistics services be represented in an ontology design pattern?* It is refined through the following sub-questions:

- SQ_1: What is an appropriate ontology engineering method in order to create reusable ODP?
- SQ_2: What are existing logistics ontologies and what are essential concepts of logistics services the could be re-used?
- SQ_3: What is a suitable ontology design pattern for logistics services?

In the following section, the applied method is presented. Afterward in section 0.3, related work is presented and the pattern is formalized and an example usage is given. Section 0.4 concludes the paper.

0.2. Method and Structure

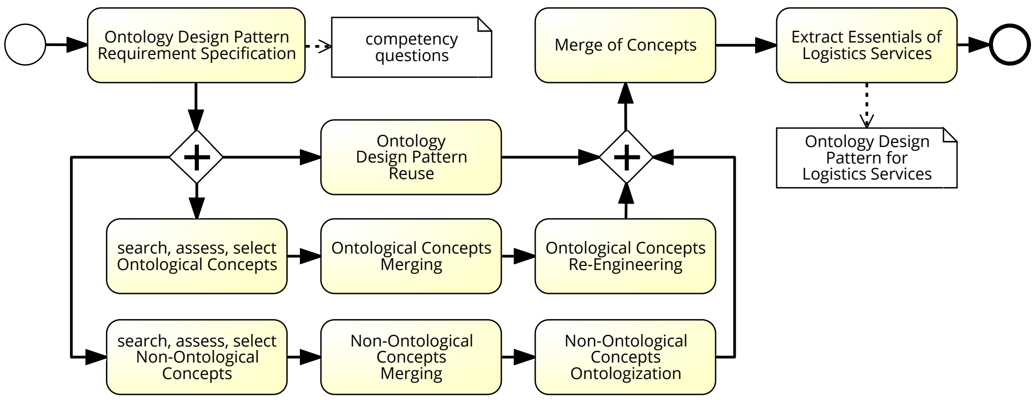

Figure 1. The method combines the NeOn methodology [31] and the combined approach for definition of ODP [27].

The applied method comprises the NeOn Methodology for Ontology Engineering [31] and the combined approach of ODP definition [27], see Figure 1. First, requirements are specified by creating competency questions. Afterward, concepts are searched, assessed and selected. Those concepts can be found in existing ODP, existing logistics ontologies concepts and non-ontological concepts of the logistics domain. By merging those concepts and extracting the essential aspects of logistics services, the final ODP for logistics services is developed. It is then presented in terms of conceptualization, formalization and an example usage. The combined method presented in Figure 1 answers sub-question SQ_1.

0.3. The LoSe Pattern

In the following subsections general modeling issues, the competency questions as well as the regarded concepts are presented. Afterward, the concepts are merged, visualized as well as informally and formally described and evaluated.

0.3.1. Ontological Modeling of the Logistics Domain

The logistics domain has not received much attention from the semantic web community yet. Some approaches of ontologies exist in literature that deal with logistics topics. However, none of them can be considered linked data in terms of the W3C-standard[1] as there are no URI (Unified Resource Identifier) nor machine-readable XML files. By now the ontologies are only available in schematic and/or graphic way. The existing ontologies are not standardized nor inter-linkable and thus they are customized and they can not be re-used due to proprietary formats. Further, conceptual overlaps can be found, which also means there are concepts significantly and frequently re-appearing in the ontologies so far. Eventually, this paper presents the first approach towards linked data representation of logistics service by bringing together concepts of existing ontologies and domain-specific aspects of logistics services within one ODP.

0.3.1.1. Competency Questions

are leading the development of the pattern and are partly taken from [14, 28]. They help to evaluate the developed ODP in the end:

CQ_1: Which actors are involved in providing a specific logistics service?

CQ_2: Which logistics services provide a specialized capability?

CQ_3: What are legal constraints that have to be considered by a composition?

CQ_4: Which resources are needed in order to fulfill a logistics service?

CQ_5: Which logistics services provide a specific transformation of conditions?

CQ_6: Which information is required to provide logistics services adequately?

CQ_7: Which LSP and transport logistics services offer a capacity of more than 7,5 t?

[1] https://www.w3.org/standards/semanticweb/data

0.3.1.2. Related ODP

In terms of reusing *existing ODP*, the existing *time interval CP*[2] [26], *Material Transformation CP*[3] [16] and *TransportPattern CP*[4] [36] are taken into account.

0.3.1.3. Re-Used Ontological Concepts

Main input for the analysis of *existing ontologies* in the context of logistics (and supply chain management) is a literature review of Scheuermann and Leukel [29] with a total of 16 ontologies. Via further research, another 12 paper were found presenting ontologies of logistics or supply chain management (or parts of it). Those ontologies were analyzed towards possible contributions to a logistics service ODP. The adopted concepts of the influencing ontologies are briefly described in the following list:

- A distinction into *physical resources* and *informational resources*, whereas the latter one is occasionally further detailed into documents and information systems, can be found in [5, 10, 19, 21, 37]. Physical resources, such as transportation and manpower [7, 14], are abstracted to capabilities as well as functional and unfunctional [sic] parameters [38].
- *Logistics objects* that are able to contain other logistics objects are described by [8, 13, 28, 35]. They are seen as passive entities (goods or passive resources, such as packaging or containers) that are transformed by active entities (active resources, such as trucks or information systems). Another paper introduces an agent that is acting on an entity with the help of a distinct equipment [9]. From this point of view, a distinction between *active resources* (acting agents) and *passive resources* (used equipment) can be derived as well.
- Performance measures and logistics *KPI* are outlined in the publications of [2, 8, 10, 14, 28].
- *Location* as a crucial aspect of logistics is emphasized by [5, 9, 28].
- *Time* plays a crucial role in all logistics activities [5, 34].
- Different Roles and *Stakeholders* are described in [2, 5, 14, 28].
- *Objectives of logistics* are refined into social, environmental and economic [2].
- *input* and *output* of logistics activities are outlined and partly refined into resources, materials and information [4]
- *Policies* are integrated by [34]
- distinct *goods* are described in the approach of [18]

0.3.1.4. Non-Ontological domain-specific Concepts

Additionally, other data models and non-ontological concepts, e.g. basic service models and essential logistics characteristics, are taken into account in order to create the logistics service ODP. The creation of an ODP of logistics services has

[2] http://www.ontologydesignpatterns.org/cp/owl/timeinterval.owl
[3] http://www.ontologydesignpatterns.org/wiki/Submissions:Material_Transformation
[4] https://wiki.auckland.ac.nz/download/attachments/52016791/TransportPattern.owl

to deal with general domain-independent service aspects as well as with domain-specific aspects of logistics. Hoxha et al. [14] break down the model of a logistics service to inputs and outputs as well as Preconditions and Results (i.e. conditions, constraints, effects). General service definitions, such as [11, 20], emphasize the usage of resources and the application of knowledge and skills within activities or processes in order to generate benefit for another entity or for the entity itself. Further, the direct interaction with the receiving entity in order to solve an existing problem is outlined. Shortly, using ones resources for the benefit of another entity is defined as service. Hence, at least the following aspects have to be conceptualized for the logistics domain: resources, benefits (transformation of conditions) and interactions (input and output).

Further aspects of the logistics domain are taken into account as essential concepts of logistics services. Basic flows of logistics comprise *informational flow* and *physical flow* [12]. Additionally, the *flow of control* is taken into account as an aspect of logistics business objects [35] within the cloud logistics paradigm. Mentzer et al. [23] describe the *7R* as the basic objectives of successful logistics activities that aim at delivering:

1. the Right product
2. with the Right information
3. to the Right location
4. in the Right time
5. in the Right quality
6. in the Right quantity
7. for the Right price

As logistics is in charge to get those aspects 'right', it has to possess the ability to influence those aspects. The manipulation of those aspects implies their *transformation* during the logistics service with regards to the customers' demands and requirements. Further, *legal constraints* are important to the logistics domain, e.g. permission to handle dangerous goods [1] or legal regulations on the allowed period of driving and rest in road transport [32].

The analyzed ontological and non-ontological concepts of the logistics domain form the basis for the essential concepts of logistics services and answer the second sub-question (SQ_2).

0.3.2. Merging the Concepts into the Pattern of LogisticsService

The several concepts are analyzed and the essential ones are integrated into the ODP for logistics service[5]. The schematic view can be seen in Figure 2. The pattern is formalized with OWL 2 Web Ontology Language [22] and expressed in description logic [3].

Focus and top-level class of the current paper is LogisticsService. The pattern of LogisticsStakeholder (light blue) is to be described in another ODP. Roughly described, a logistics service is measured by service level agreements, has mandatory (such as legal regulations) and non-mandatory constraints as well as certain capabilities. Stakeholders consume logistics services that consume resources. With

[5] https://github.com/Michael-Gloeckner/LoSe_ODP

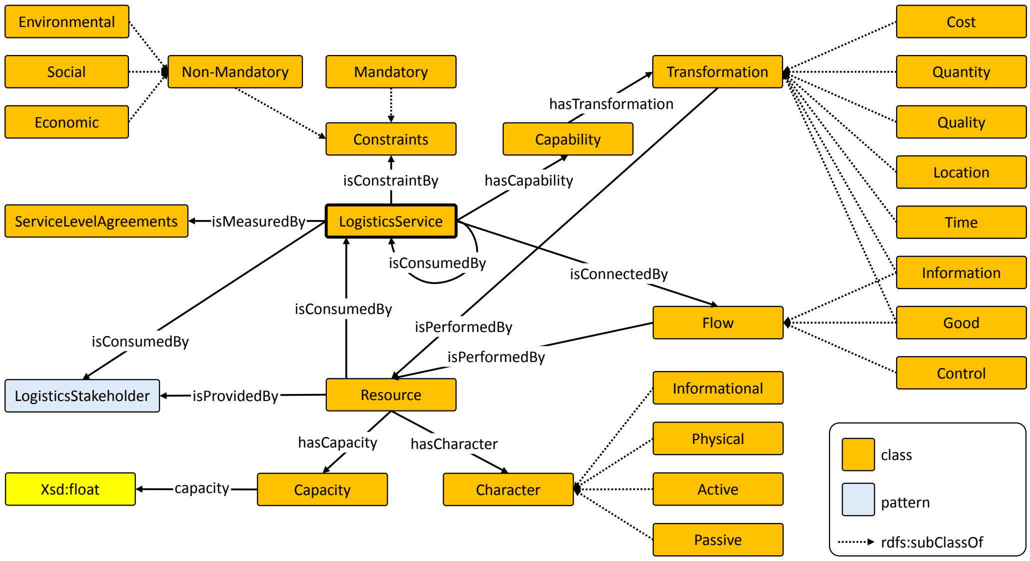

Figure 2. Schematic view of the ontology design pattern for logistics services.

those resources they perform transformations. Flows connect them with each other and require active resources (see axiom 1). Information and Control are obligatory (see axiom 2). Both obligatory flows are performed by informational resources (see axiom 3). The flow of goods is performed by physical resources (see axiom 4). Transformations are performed by active resource (see axiom 5). The capability of a logistics service always consists of at least one transformation (see axiom 6). One logistics service is always capable of at least one capability (see axiom 7). Through transitivity, the conclusion that every LogisticsService has to incorporate at least 1 active resource can be drawn (axioms 5 - 7). Resources with an active character (such as trucks, fork lifts, conveyor or sorting machines) are able to move goods actively or to transform information actively (such as Transport Management Systems). Resources with a passive character are e.g. entities that contain goods (such as packaging or containers) or information (such as documents, pick lists, contracts). Constraints that are mandatory (e.g. laws, permissions, regulations) or of other objectives (e.g. ecological or social objectives, such as CO_2-reduced) influence the logistics services. The character of a resource can be either informational or physical (see axiom 8) and either active or passive (see axiom 9).

The presented ODP[6] is derived from existing concepts of the logistics domain and is able to represent logistics services. Thus, SQ_3 is answered.

$$\mathsf{Flow} \sqsubseteq \mathsf{isPerformedBy.Resource} \sqcap \mathsf{hasCharacter.Active} \tag{1}$$

$$\mathsf{LogisticsService} \sqsubseteq \forall \mathsf{isConnectedBy.Information} \sqcap \forall \mathsf{isConnectedBy.Control} \tag{2}$$

[6] https://github.com/Michael-Gloeckner/LoSe_ODP/blob/master/LoSe_ODP.owl

$$\mathsf{Information} \sqcup \mathsf{Control} \sqsubseteq \mathsf{isPerformedBy.Resource} \sqcap \mathsf{hasCharacter.Informational} \quad (3)$$

$$\mathsf{Good} \sqsubseteq \mathsf{isPerformedBy.Resource} \sqcap \mathsf{hasCharacter.Physical} \quad (4)$$

$$\mathsf{Transformation} \sqsubseteq \mathsf{isPerformedBy.Resource} \sqcap \mathsf{hasCharacter.Active} \quad (5)$$

$$\mathsf{Capability} \sqsubseteq \ 1 \ \mathsf{hasTransformation.Transformation} \quad (6)$$

$$\mathsf{LogisticsService} \sqsubseteq \ 1 \ \mathsf{hasCapability.Capability} \quad (7)$$

$$\mathsf{Informational} \equiv \neg \mathsf{Physical} \quad (8)$$

$$\mathsf{Active} \equiv \neg \mathsf{Passive} \quad (9)$$

0.3.3. Evaluation

The evaluation is conducted with the 'Framework for Evaluation in Design Science Research' (FEDS) of [33]. The *quick & simple* strategy is chosen, as the designed artifact is of small and simple construction, with low social and technical risk and uncertainty. The approach of an illustrative scenario [25] is taken into account in order to evaluate the developed ODP. The evaluation is summative (judge the extent that the outcomes match expectations) and located in the middle between artificial and naturalistic: two anonymized (due to privacy reasons) example processes of internationally operating LSP are represented with the help of the ODP proofing the concept.

Example 1

LSP 1 offers the service 'off-loading of long-distance truck transport' within the network. This comprises the removing of all physical entity from the truck and follows the steps of (1) getting freight documents from the driver, (2) identification, scanning and off-loading of package, (3) bringing package to pallet space and (4) scanning and forwarding protocol. The input flows are informational (freight document with goods identification, quantity, shipper, consignee) and physical (pallets containing goods). The control flow is then later on added, when the logistics service is composed with other services. The control flow would be triggered when the truck arrives at the warehouse. The transformations aim at the dimensions of location (truck to pallet space), time (the process takes a certain amount of time), costs (occuring for the provision of the service), information (state of the pallet containing a certain good changes from in transfer to in warehouse, and the location information is changed as well). The necessary active resources for this comprise staff, forklifts, scanners (physical), warehouse management system (WMS) (informational). The passive resources comprise pallets (physical) and freight documents (informational)[7]. Important KPI and SLA comprise the time consumed, the accuracy of identification of goods, identification of pallet space and the matching of the latter two.

Example 2

LSP 2 offers the service 'order picking air' within the network. This comprises the steps of (1) pallet picking, (2) scanning, (3) transportation to air packing station, (4) loading aircraft container, (5) scanning, (6) transferring aircraft container to outbound, (7) scanning. The input flows are informational (electronic data on handheld: flight number, start time and end time (critical due to flight schedule), aircraft type, terminal, position (aircraft parking space), pallet space) and physical (aircraft containers, goods). The control flow is then later on added, the trigger signal would be of timely manner according to flight schedule. The transformations aim at the dimensions of product (the right products have to be collected), location (goods from warehouse to packing station to outbound), time, quantity (certain amount is picked), cost, information (state of the pallet from warehouse to packing, state of the goods from pallet to aircraft container, state of the aircraft container from packing to outbound). The necessary active resources for this comprise staff, forklift, tractor unit and scanner (physical) as well as a WMS (informational). Passive resources are pallet, aircraft container, trolley (physical) as well as pick lists and loading document (informational). Important KPI and SLA comprise the time consumed, picking accuracy, throughput. Electronic services are invoked to transfer data, identification of required aircraft container type according to aircraft type.

Querying

With regards to the competency questions in section 0.3.1 the following 2 queries are presented. The first one, allows to find a list of LSP and their services that are able to perform the process of the first example above:

```
@prefix LoSe_ODP: <https://github.com/Michael-Gloeckner/LoSe_ODP#>
SELECT LogisticsStakeholder LogisticsService
FROM <https://github.com/Michael-Gloeckner/LoSe_ODP#>
WHERE {
LoSe_ODP:staff rdfs:subClassOf LoSe_ODP:Resource.
LoSe_ODP:forklifts rdfs:subClassOf LoSe_ODP:Resource.
LoSe_ODP:scanners rdfs:subClassOf LoSe_ODP:Resource.
LoSe_ODP:Resource LoSe_ODP:hasCharacter LoSe_ODP:Physical.
LoSe_ODP:Resource LoSe_ODP:isProvidedBy LoSe_ODP:LogisticsStakeholder.
}
```

The second query seeks to find a transportation resource (for a transformation of a location) with a capacity higher than 7.5 t. For this example, two classes of

[7]Even though freight documents are physically existent as hard copies, their purpose is to carry information. Since digitalization is an approaching issue, it is likely that such documents will be available in the future as files or database entries only.

trucks are introduced first and afterwards they could be queried to answer the following competency question CQ_7: "Which LSP and transport logistics services offer a capacity of more than 7,5 t?"

```
@prefix LoSe_ODP: <https://github.com/Michael-Gloeckner/LoSe_ODP#>
LoSe_ODP:Truck_40 rdf:type owl:Class ;
                  rdfs:subClassOf LoSe_ODP:Resource ;
                  LoSe_ODP:hasCapacity LoSe_ODP:Capacity ;
                  LoSe_ODP:Capacity LoSe_ODP:capacity 40 ;
                  rdfs:comment "Truck that can transport up to 40 tons."@en .
LoSe_ODP:Truck_7.5 rdf:type owl:Class ;
                  rdfs:subClassOf LoSe_ODP:Resource ;
                  LoSe_ODP:hasCapacity LoSe_ODP:Capacity ;
                  LoSe_ODP:Capacity LoSe_ODP:capacity 7.5 ;
                  rdfs:comment "Truck that can transport up to 7.5 tons."@en .

SELECT Capacity LogisticsService LogisticsStakeholder
FROM <https://github.com/Michael-Gloeckner/LoSe_ODP#>
WHERE {
LoSe_ODP:location rdfs:subClassOf LoSe_ODP:Transformation.
LoSe_ODP:Capability LoSe_ODP:hasTransformation LoSe_ODP:Transformation.
LoSe_ODP:LogisticsService LoSe_ODP:hasCapability LoSe_ODP:Capability.
LoSe_ODP:Resource LoSe_ODP:isConsumedBy LoSe_ODP:LogisticsService.
LoSe_ODP:Resource LoSe_ODP:hasCapacity LoSe_ODP:Capacity.
LoSe_ODP:Capacity LoSe_ODP:capacity >=7.5.
}
```

0.4. Conclusion and Future Work

The creation of a CP for logistics services holds enormous potential to support digitalization and collaboration between various actors of the logistics service industry in general and for the emerging cloud logistics paradigm in particular. With a derivation of all services within a network from a unique blueprint, basic connectable lego bricks of logistics can be achieved. Hence, resources, functions and capabilities can be easily virtualized, an ontological connection (with rdfs:sameAs) between similar concepts of different LSP can be set up. Thus, the semantic gap between LSP can be closed. The paper presents the first approach towards an ontology design pattern for logistics services. The ODP describes the essential concepts of logistics services. Since it forms a generic basic building block with standardized connection points (LoSe_ODP:Flow).

By enabling such a lego brick system, the paradigm of cloud logistics can be made accessible in a more easy and convenient way to practitioners. Implications for researchers is the first approach towards linked data in logistics. Further research steps have to focus on further ODPs in the conctext of logistics.

Acknowledgments.

Special acknowledgment is dedicated to Bettina Klimek of the research group Agile Knowledge Engineering and Semantic Web (AKSW) at the Institute for Applied Informatics (InfAI). Her insights of the semantic web community eminently improved the structural and formal quality of the paper. The work presented in this paper was funded by the German Federal Ministry of Education and Research within the project *Logistik Service Engineering und Management* (LSEM). More information can be found under the reference BMBF 03IPT504X and on the website `www.lsem.de`.

Bibliography

[1] *ADR - European Agreement Concerning the International Carriage of Dangerous Goods by Road: Applicable as from 1 January 2013*. United Nations, New York [etc.], 2012. ISBN 978-92-1-139143-5.

[2] Nilesh Anand, Mengchang Yang, J.H.R. van Duin, and Lori Tavasszy. Genclon: An ontology for city logistics. *Expert Systems with Applications*, 39 (15):11944–11960, 2012. ISSN 09574174. doi: 10.1016/j.eswa.2012.03.068.

[3] Franz Baader. *The description logic handbook: Theory, implemention, and applications*. Cambridge Univ. Press, Cambridge [u.a.], 2. repr edition, 2004. ISBN 9780521781763.

[4] Charu Chandra and Armen Tumanyan. Organization and problem ontology for supply chain information support system. *Data & Knowledge Engineering*, 61(2):263–280, 2007. ISSN 0169023X. doi: 10.1016/j.datak.2006.06.005.

[5] Laura Daniele and Luis Ferreira Pires. An ontological approach to logistics. In M. Zelm, M.J. van Sinderen, and G. Doumeingts, editors, *Enterprise Interoperability, Research and Applications in the Service-oriented Ecosystem, IWEI 2013*, pages 199–213, Surrey, UK, 2013. ISTE Ltd, John Wiley & Sons, Inc. URL `http://doc.utwente.nl/88351/`.

[6] Werner Delfmann and Falco Jaekel. The cloud - logistics for the future? discussionpaper. URL `http://www.bvl.de/misc/filePush.php?id=18910&name=Discussionpaper+Cloud+Logistis`.

[7] Tobias Engel, Manoj Bhat, Venkatesh Vasudhara, Suparna Goswami, and Helmut Krcmar. An ontology-based platform to collaboratively manage supply chains. In *25th Annual Conference of the Production and Operations Management Society (POMS)*, pages 1–10, 2014. URL `https://www.pomsmeetings.org/ConfProceedings/051/FullPapers/Final%20Full%20length%20Papers/051-0705.pdf`.

[8] M. Fayez, L. Rabelo, and M. Mollaghasemi. Ontologies for supply chain simulation modeling. In *Winter Simulation Conference, 2005*, pages 2364–2370, 2005. doi: 10.1109/WSC.2005.1574527.

[9] Guido L. Geerts and Daniel E. O'Leary. A supply chain of things: The eaglet ontology for highly visible supply chains. *Decision Support Systems*, 63:3–22, 2014. ISSN 01679236. doi: 10.1016/j.dss.2013.09.007.

[10] Silvio Gonnet, Marcela Vegetti, Horacio Leone, and Gabriela Henning. Scontology. In Maria Manuela Cruz-Cunha, Bruno Conceicao Cortes, and Goran

Putnik, editors, *Adaptive technologies and business integration*, pages 137–158. Idea Group Reference, Hershey PA, 2007. ISBN 9781599040486. doi: 10.4018/978-1-59904-048-6.ch007.

[11] Christian Grönroos. *Service management and marketing: A customer relationship management approach*. Wiley, Chichester [u.a.], 2. ed. edition, 2000. ISBN 9780471720348.

[12] Timm Gudehus and Herbert Kotzab. *Comprehensive Logistics*. Springer Berlin Heidelberg, Berlin, Heidelberg, 2012. ISBN 978-3-642-24366-0. doi: 10.1007/978-3-642-24367-7.

[13] Bernhard Holtkamp, Sebasti Steinbuss, Heiko Gsell, Thorsten Loeffeler, and Ulrich Springer. Towards a logistics cloud. In *2010 Sixth International Conference on Semantics Knowledge and Grid (SKG)*, pages 305–308, 2010. doi: 10.1109/SKG.2010.46.

[14] Julia Hoxha, Andreas Scheuermann, and Stephan Bloehdorn. An approach to formal and semantic representation of logistics services. In *Proceedings of the Workshop on Artificial Intelligence and Logistics (AILog), 19th European Conference on Artificial Intelligence (ECAI 2010), Lisbon, Portugal*, pages 73–78, 2010.

[15] Christoph Klotzer and Alexander Pflaum. Cyber-physical systems as the technical foundation for problem solutions in manufacturing, logistics and supply chain management. In *2015 5th International Conference on the Internet of Things (IOT)*, pages 12–19, 2015. doi: 10.1109/IOT.2015.7356543.

[16] Adila Krisnadhi. Content ontology design pattern: material transformation, 2014. URL `http://descartes-core.org/ontologies/mt/1.1/MaterialTransformationPattern.owl`.

[17] John Langley and Mindy Long. 2016 third-party logistics study: The state of logistics outsourcing: Results and findings of the 20th annual study. 20, 2016. URL `http://www.otmbe.org/infotheek/downloads/informatie/652-3pl-report/file`.

[18] Dongmin Li, Xiao Xue, Shuhui Ding, and Cuiyun Li. Owl 2 based validation and modeling of logistics domain ontology. *International Journal of Artificial Intelligence and Application for Smart Devices*, 2(2):1–8, 2014. URL `www.sersc.org/journals/IJAIASD/vol2_no2/1.pdf`.

[19] Wenfeng Li, Ye Zhong, Xun Wang, and Yulian Cao. Resource virtualization and service selection in cloud logistics. *Journal of Network and Computer Applications*, 36(6):1696–1704, 2013. ISSN 10848045. doi: 10.1016/j.jnca.2013.02.019.

[20] R. F. Lusch and Stephen L. Vargo. Service-dominant logic: Reactions, reflections and refinements. *Marketing Theory*, 6(3):281–288, 2006. ISSN 1470-5931. doi: 10.1177/1470593106066781.

[21] Azad M. Madni, Weiwen Lin, and Carla C. Madni. Ideontm: An extensible ontology for designing, integrating, and managing collaborative distributed enterprises. *Systems Engineering*, 4(1):35–48, 2001. ISSN 1098-1241. doi: 10.1002/1520-6858(2001)4:1⟨35::AID-SYS4⟩3.0.CO;2-F.

[22] Deborah McGuinnes and Frank van Harmelen. Owl 2 web ontology language document overview (second edition): W3c recommendation 11 december 2012, 2012. URL `https://www.w3.org/TR/owl2-overview/`.

[23] John T. Mentzer, Daniel J. Flint, and John L. Kent. Developing a logistics service quality scale. *Journal of Business Logistics*, 20(1):9, 1999. ISSN 07353766.

[24] Michael P. Papazoglou. Cloud blueprints for integrating and managing cloud federations. In Maritta Heisel, editor, *Software service and application engineering*, volume 7365 of *Festschrift*, pages 102–119. Springer, Berlin, 2012. ISBN 978-3-642-30834-5. doi: 10.1007/978-3-642-30835-2_8.

[25] Ken Peffers, Marcus Rothenberger, Tuure Tuunanen, and Reza Vaezi. Design science research evaluation. In Ken Peffers, editor, *Design science research in information systems*, volume 7286 of *Lecture Notes in Computer Science*, pages 398–410. Springer, Heidelberg, 2012. ISBN 978-3-642-29862-2. doi: 10.1007/978-3-642-29863-9_29.

[26] Valentina Presutti. Content ontology design pattern: time interval, 2010. URL `http://www.ontologydesignpatterns.org/cp/owl/timeinterval.owl`.

[27] Valentina Presutti and Aldo Gangemi. Content ontology design patterns as practical building blocks for web ontologies. In Qing Li, editor, *Conceptual modeling - ER 2008*, volume 5231 of *LNCS sublibrary. Information systems and application, incl. Internet/Web, and HCI*, pages 128–141. Springer, Berlin, 2008. ISBN 978-3-540-87876-6. doi: 10.1007/978-3-540-87877-3_11.

[28] Andreas Scheuermann and Julia Hoxha. Ontologies for intelligent provision of logistics services. In *ICIW 2012 : The Seventh International Conference on Internet and Web Applications and Services*, pages 106–111, 2012.

[29] Andreas Scheuermann and Joerg Leukel. Supply chain management ontology from an ontology engineering perspective. *Computers in Industry*, 65(6):913–923, 2014. ISSN 01663615. doi: 10.1016/j.compind.2014.02.009.

[30] Tomi Solakivi, Juuso Töyli, and Lauri Ojala. Logistics outsourcing, its motives and the level of logistics costs in manufacturing and trading companies operating in finland. *Production Planning & Control*, 24(4-5):388–398, 2013. ISSN 0953-7287. doi: 10.1080/09537287.2011.648490.

[31] Mari Carmen Suárez-Figueroa, Asunción Gómez-Pérez, Enrico Motta, and Aldo Gangemi, editors. *Ontology Engineering in a Networked World*. Springer Berlin Heidelberg, Berlin, Heidelberg, 2012. ISBN 978-3-642-24793-4. doi: 10.1007/978-3-642-24794-1.

[32] THE EUROPEAN PARLIAMENT. Regulation on the harmonisation of certain social legislation relating to road transport. URL `http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02006R0561-20150302&from=EN`.

[33] John Venable, Jan Pries-Heje, and Richard Baskerville. Feds: A framework for evaluation in design science research. *European Journal of Information Systems*, 2014. ISSN 0960-085X. doi: 10.1057/ejis.2014.36.

[34] Xiaohuan Wang, T. N. Wong, and Zhi-Ping Fan. Ontology-based supply chain decision support for steel manufacturers in china. *Expert Systems with Applications*, 40(18):7519–7533, 2013. ISSN 09574174. doi: 10.1016/j.eswa.2013.07.061.

[35] Norbert Weißenberg and Ulrich Springer. Cloud process modeling for the logistics mall-object-aware bpm for domain experts. *Open Journal of Mobile*

Computing and Cloud Computing, 1(2):31–49, 2014.

[36] Brandon Whitehead. Content ontology design pattern: Transportpattern, 2013. URL `https://wiki.auckland.ac.nz/download/attachments/52016791/TransportPattern.owl`.

[37] Milan Zdravković, Herve Panetto, Miroslav Trajanović, and Alexis Aubry. An approach for formalising the supply chain operations. *Enterprise Information Systems*, 5(4):401–421, 2011.

[38] Ye Zhong, Wenfeng Li, Wenjing Guo, Lanpeng Gong, and Gabriel Lodewijks. A method of modeling and service encapsulation on cloud logistics resources. In *2015 IEEE 19th International Conference on Computer Supported Cooperative Work in Design (CSCWD)*, pages 383–388, 2015. doi: 10.1109/CSCWD.2015.7230990.

3.2 Executive Summary

The paper contains the technical basis of the *landscape* that facilitates the engineering of cloud logistics service. With the help of the NeOn methodology and a literature review, the field of ODP and other ontological sources in the context of logistics are analyzed, existing approaches are conceptualized, merged, and the essentials of logistics services are extracted. With those essentials, the *Logistics Service Ontology Design Pattern (LoSe ODP)* is developed. Competency questions and some first usage examples complement the paper. The analytical and design method is the NeOn methodology following Suárez-Figueroa et al. [2012]. The paper answers RQ_2 (see Section 1.2) by dividing it into three sub-questions:

- What is an appropriate ontology engineering method in order to create reusable ODP?
- What are existing logistics ontologies and what are essential concepts of logistics services the could be re-used?
- What is a suitable ontology design pattern for logistics services?

The semantic web community has not paid much attention on the logistics domain, yet. There are no ODP dealing with logistics issues in literature. Some approaches of ontologies exist in literature that deal with logistics topics. However, none of them can be considered linked data in terms of the W3C-standard 1 as there are no URI (Unified Resource Identifier) nor machine-readable XML files. By now, the ontologies are only available in schematic and/or graphic way. This gap is closed by the current paper. Eventually, this paper presents the first approach towards linked data representation of logistics services by bringing together concepts of existing ontologies and domain-specific aspects of logistics services within one ODP, see Figure 3.1. Main aspects that are essential to describe logistics services are the *7 Rs* of logistics as the base for the *transformation* dimensions of the services. Further, the consumed *resources* are important for the description, connectivity, and SLAs. Resources could be either informational or physical on the one side, and on the other either active or passive. Another important aspect are the several *flows* that characterize a logistics service, i.e. goods, information, control in order to describe the input and output of each service. Eventually, some first application examples are given in order to have a rough evaluation and some example queries are given in order to demonstrate how such ODP, and the resulting ontologies that contain explicit knowledge of a logistics network, can be used. Through reasoning and interference, implicit knowledge can be derived. This semantic approach enables a LI to bridge existing syntactical gaps and make logistics resources from heterogeneous LSP compatible with each other.

In terms of contribution type level (see Table 1.2) and the kind of knowledge contribution (see Table 1.9), the artifact of the paper can be characterized as follows: The

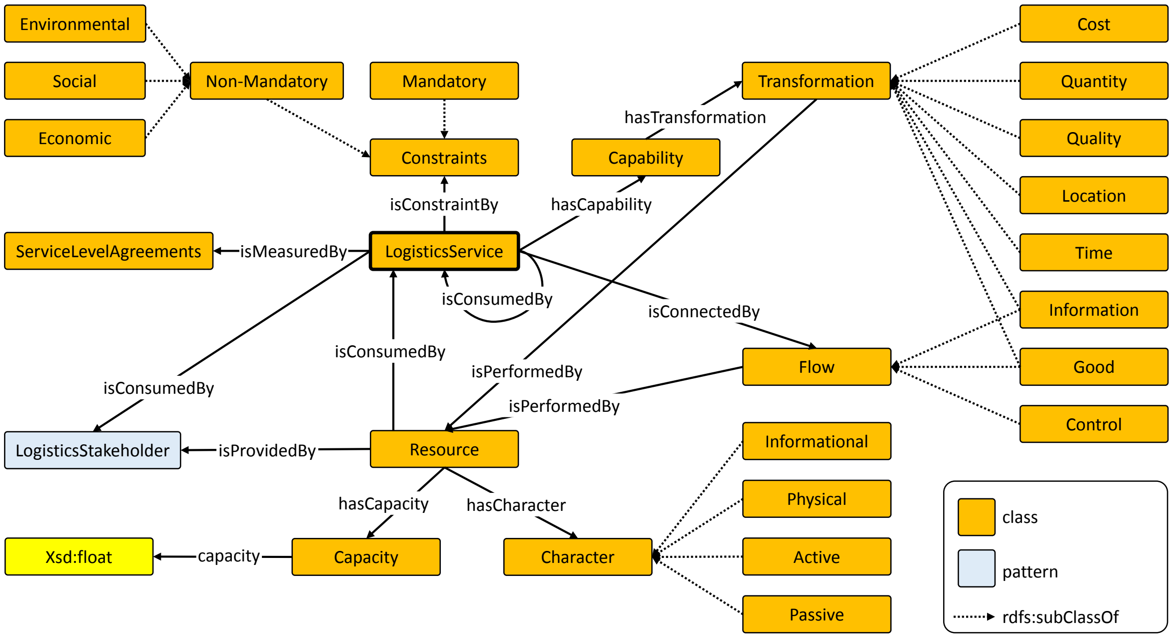

Figure 3.1: Schematic view of the ontology design pattern for logistics services.

concept of an ODP is a known solution that is adopted to a new problem field. Thus, it can be considered as an exaptation. The LoSe ODP can be applied to a range of problems and specialized according to special conditions of several logistics networks and constraints, thus it can be located on the second level of contribution type.

This papers complements the conceptual foundation for the engineering of cloud logistics service description ("service landscape") (#1) and lays the technical foundation for a semantic approach of cloud logistics service description. The results are further used for the prototype (#6), as well as transitively in the consolidation and research roadmap (#8).

4 Map - Conceptual

Glöckner, Michael; Augenstein, Christoph; Ludwig, André (2014): Metamodel of a Logistics Service Map. In: Abramowicz, Witold; Kokkinaki, Angelika (Ed.) Business Information Systems - 17th International Conference, BIS 2014, Larnaca, Cyprus, May 22 - 23, 2014. In: Lecture Notes in Business Information Processing, Vol. 176. Springer International Publishing. Pp 185-196. [Glöckner, Augenstein, et al., 2014]

4.1 "Metamodel of a Logistics Service Map"

Table 4.1: Meta data of the publication (Map - Conceptual).

DOI	10.1007/978-3-319-06695-0_16
URL	`http://link.springer.com/chapter/10.1007/978-3-319-06695-0_16`
Type	Conference Paper, Book Chapter
Publication in	17th International Conference on Business Information Systems, BIS 2014, Larnaca, Cyprus, May 22-23, 2014, Proceedings
Editor	Abramowicz, Witold; Kokkinaki, Angelika
Series Title	Lecture Notes in Business Information Processing (LNBIP)
ISSN / ISBN	1865-1348 (ISSN), 978-3-319-06694-3 (ISBN)
Publisher	Springer International Publishing
Place of Publication	Larnaca, Cyprus (BIS 2014); Switzerland (Journal)
Ranking	CORE: B-ranked (conference) VHB: C-ranked (proceedings) h-index: 27

Metamodel of a Logistics Service Map

Michael Glöckner, Christoph Augenstein, and André Ludwig

Information Systems Institute,
University of Leipzig
Grimmaische Str. 12, 04109 Leipzig, Germany
{gloeckner,augenstein,ludwig}@wifa.uni-leipzig.de
http://www.wifa.uni-leipzig.de/islog

Abstract. With the principle of division of labor in logistics, an integrator can focus on planning and monitoring within a network, while subsidiary logistics service providers (LSPs) are responsible for the actual physical manipulation of goods. Because of heterogeneous service descriptions, processes and IT-systems, the integrator requires a platform that provides the ability to interact with LSPs and to plan, execute and monitor contracts for integrator's customers. Such an integration platform is currently developed in the research project Logistics Service Engineering & Management. Crucial to such a platform is the ability to maintain a complete catalog and to efficiently identify and choose appropriate services. In this paper a metamodel-based approach is presented facing these requirements.

Keywords: Service Map, Metamodel, Logistics, Service Engineering and Management, Service Repository.

1 Introduction

Logistics is the applied science on executing orders by managing physical goods in a matter of space and time [1]. In a broader sense, it further deals with tasks of planning, operating and monitoring the systems that create physical goods and immaterial services. With big relevance of information exchange and automation in nowadays business also information flows grow more important in logistics. Accordingly, flows of both, physical goods and information, need to be considered in a comprehensive logistics system [1]. In consequence, new business models emerged in logistics industry. Most of these business models are based on a division of labor and of responsibility: logistics integrators (e.g. fourth party (4PL) or lead logistics service provider (LLP)) focus on planning and monitoring aspects of the flows of goods and information within a network of logistics providers. In contrast, process execution and actual physical manipulation of goods are realized by specialized logistics service providers (LSPs) acting as subcontractors for the logistics integrator [2, 3]. By combining offered services of the LSPs to composite services, the integrator is able to fulfill logistics contracts up to entire supply chains for its customers.

W. Abramowicz and A. Kokkinaki (Eds.): BIS 2014, LNBIP 176, pp. 185–196, 2014.

Confronted with low margins in logistics in general, an integrator has to choose the best available option for each task of a customer request. Thus, to plan and to operate a complex logistics service the integrator has to manage a variety of providers, their services and finally has to integrate with at least parts of their heterogeneous IT-systems of [1, 4, 5]. Each of the LSPs maintains its own systems, is capable of delivering a specific set of services and owns a specific set of resources in order to fulfill customer requests. Moreover, each LSP maintains a unique way of describing its services, thereby emphasizing different aspects of services and underlying concepts. To overcome this situation and to efficiently plan and operate a logistics contract, the integrator needs a solution to uniformly manage subsidiary providers as well as their systems and resources.

The Logistics Service Engineering & Management-platform (LSEM-platform) [6] makes use of the service-oriented design paradigm [7, 8] which helps to overcome some of the above aspects on a technological level. Modularization and loose-coupling of artifacts allow for a better exchangeability and fixed contracts allow for a more standardized way of describing interfaces in terms of necessary inputs and resulting outputs. As mentioned above, logistics is about handling goods and with this a service-oriented approach has to combine services from "the real world" and services which support the flow of goods by exchanging information between involved parties. In terms of service-oriented architectures (SOA) there are approaches addressing these difficulties when combining physical as well as non-physical services (for examples see: [9, 10]). However, on a more conceptual level in terms of describing the services themselves (e.g. handling of diverse service definitions or consideration of mutually exclusive service modeling approaches) further methods have to be developed.

Planning, operation and management of logistics contracts involve a multitude of providers and their services with differing service descriptions and resources. Thus, there is a need for a construction system which maintains a catalog of services and the originating providers and is moreover capable of supporting the integrator in order to efficiently identify and integrate adequate services for composite logistics services. A first draft towards a modular construction system for LSEM is already presented in [11] - the logistics service map (SM). It supports identification and integration of services on the LSEM-platform primarily at the beginning of a four-phase life-cycle. The logistics SM supports service composition in that it provides functionality for structuring, presenting and retrieval of services. Up to now, an appropriate metamodel for the integration of the SM-approach in the LSEM-platform is missing.

The contribution of this paper in particular is the development of such a metamodel for the logistics SM. The second section introduces the existing and to be developed parts of the LSEM-platform, that have essential influence on the metamodel. In section 3 related work is presented, compared to findings of section 2 and thus, provides further influence on the development described in section 4. After a critical appraisal, the paper ends with summary.

2 Logistics Service Engineering and Management

This section introduces parts of the LSEM-platform, a service life-cycle, the theoretical basics of a repository and its metamodel. Further, we focus on important characteristics of a service map concerning logistics issues. From these concepts we derive the integration constraints and essential criteria of the SM metamodel.

2.1 Service Life-Cycle

LSEM introduces a four-phase service life-cycle which supports a consistent and robust service development, allows for a sustainable execution and an orderly termination of logistics services [6]:

Servitization is the initial phase for developing atomic services. This phase includes aspects like 'analysis and design' [7], 'identifying and modeling' [12] or 'conceptualization and analysis' [13]. During this stage, the logistics integrator develops the basic services that are stored in the repository. Each LSP who wants to participate on the platform, registers itself and publishes the services he is capable of. Thus, this phase is not repeated on a regular base but only if new providers join the platform or if existing providers widen their service portfolio. The result of this phase is a set of atomic services the integrator uses to develop composite logistics services in order to fulfill customer contracts. The main issue here is to identify appropriate atomic services and their providers from a given portfolio of processes and capabilities.

Development involves all activities concerning the systematic composition of atomic services in order to fulfill customers' needs. Hence, facets like 'development and testing' [7], 'publishing' [12, 14], 'orchestration' [14] or 'development and testing' [13, 14] are regarded in this phase. In specific, the phase comprises modeling and simulation steps in order to construct and validate composite logistics services. The main concerns are to retrieve needed services (atomic or already composed) by an appropriate categorization as well as available providers, their associated resources and offered service level agreements (SLA).

Operation covers the field of implementation and actual execution. Correspondingly, aspects like 'deployment and execution' [12, 13], 'monitoring' [12, 14] or 'payment processing' [13] are contained in this field. During runtime, the integrator has to receive latest information about the current situation in its managed network. This information supports the operational management and error treatment. The main issues for this phase are the finance and accounting aspects as well as the monitoring aspects.

Retirement addresses the functions after the actual runtime of a service. This includes 'maintenance' [14] and 'retirement and rebinding' [13]. Further, a systematic performance analysis based on long-term monitoring for the evaluation of the LSP is done. This helps assessing the subcontractors on a long-term data base and provides an evident picture of their performance parameters for improved future planning issues.

Essential criteria, for the metamodel concept of the SM, are mainly focused in the first two phases that maintain a structured overview on the services of the platform, see also Fig. 1. We proceed with an overview of the influencing concepts and components of the LSEM-platform which support service engineering in particular and derive their impact on the metamodel.

2.2 Repository

The already mentioned service repository [15] of the platform is a crucial feature for managing necessary services and their descriptions. In the repository all artifacts related to services are stored and provided for platform tools in order to define, develop or monitor logistics services. On a *technical level*, the repository is a typical client-server solution. On the server side services and service models are stored in a content repository (Java Specification Request, JSR 170) which has a flat structure and no limitations regarding content to be added. The repository client is implemented using Java and components from the Eclipse framework. It allows browsing as well as synchronizing local working copies from platform tools. On a *conceptual level*, the repository and related components are part of the Service Modeling Framework (SMF) using a model-driven approach. The framework sees to make information about services in the repository available to the platform tools in that it interprets service models and extracts necessary information in order to create or update other service models. As a result, SMF provides a continuous modeling of services to platform users without the need of repeatedly modeling the same facts. Hence, we are able to provide support for LSEM-platform tools which are used in different phases of the life-cycle and which are used to add or update certain aspects of services like the process model, the interface definition or a textual description. These examples also show why a model-driven approach is necessary in order to uniformly handle these service aspects. They are heterogeneous in scope and in used language (modeling language). Thus, we need an approach which is capable of handling different types of service descriptions, i.e. models. For a more detailed explanation we refer to [15]. At its core, SMF is based on a metamodel, called common service model (CSM). The metamodel is kept simple and only consists of a few essential elements and their relationships, namely services, models, model elements and type information. With CSM we are able to interconnect models and model elements from different models, respectively. Purpose of the CSM is to uniformly interweave distinct service models each representing unique aspects of a service and thus on model-level allows for a generic and modular service model.

Development of a logistics SM is thus strongly related to SMF and its model-based concepts. Optimally, the SM also uses a model-driven approach so that information from early phases of the life-cylce can be transparently reused in later phases. Moreover, we emphasize the conceptual aspects of the repository as important for the metamodel development, see also Fig. 1. We now continue with the characteristics of the SM itself to identify further criteria for its metamodel.

2.3 Service Map for Service Engineering and Management

Offering a customizable approach for a logistics integrator, the logistics SM satisfies the needs for supporting the engineering and management of logistics services. It comprises functionality of both the addressed phases of the service life-cycle and the conceptual aspects of the repository, as shown in Fig. 1.

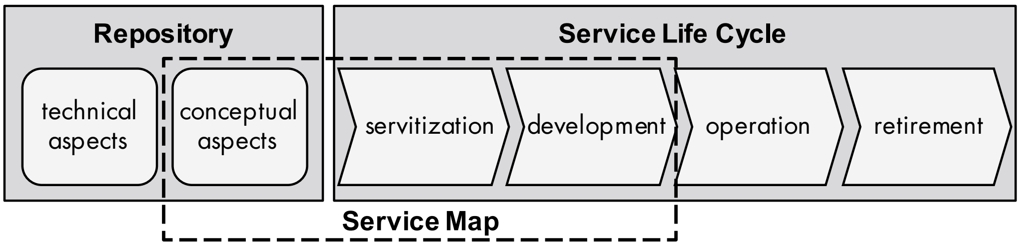

Fig. 1. Service Map addresses multiple phases and concepts in LSEM

The definition given in [11] outlines the emphasized phases by the functionality of a modular service construction system and the regarded relations between services. This implies the creation of atomic services (phase of servitization) that could be composed to composite services (phase of development). The conceptual aspects of the repository, like catalog function and the retrieval of services, are included with the structured categorization-pattern and the modular service construction functionality. Further, the SM includes different granularity levels and viewpoints from basic service description up to a category overview. Fig. 2 shows a simple example instance of a SM.

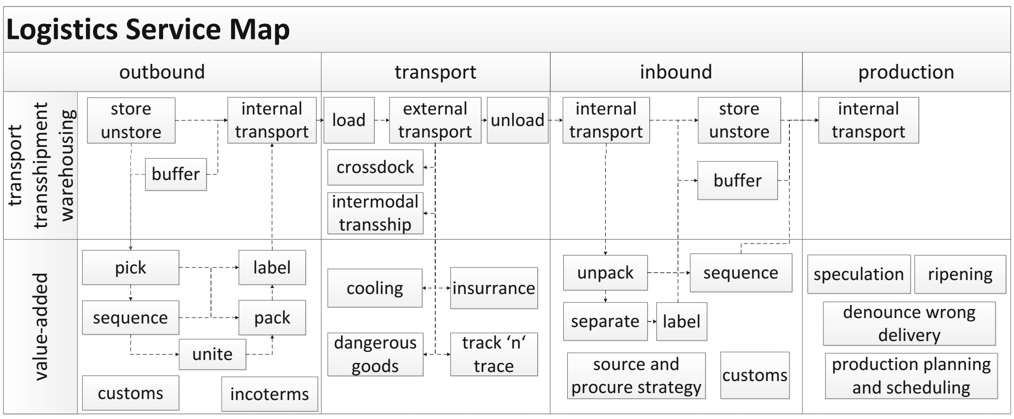

Fig. 2. Exemplary SM with two dimensions: ’classic logistics function vs. value-added’ and ’stage-specific’. Dashed arrows mark compatible services for composition.

With this approach, a logistics integrator is supported in retrieving services in different use cases. (a) Adding a new LSP to the network and match its offered services to the existing set of services in a logistics network by adding the new LSP to the provider list of the particular service. (b) Developing a new composite service to meet a specific customer's need by selecting and composing services from the SM. Service-specific information and attributes can be displayed when changing the selected granularity to a more detailed level to foster planning and monitoring. Moreover, the unique standard of the used set of services within a network and the visualization foster a precise mediation and communication between all stakeholders during the whole service life-cycle. (c) Finding compensational service or provider, when realizing the urgency for replanning or elimination of errors because of unpredictable disturbance in the network.

Consequently, a SM should be a core element of a service-oriented engineering and management platform and integrated by an appropriate metamodel due to the heterogeneous tools, models and platforms of the subcontractors.

2.4 Logistics

Since the integrator focuses on the engineering and management of logistics services in particular and a connection and composition of services in general only stands to reason within a distinct field of interest, a service map is always domain-specific. Blake [13] also proposes a domain-specific conceptualization and analysis in his presented service life-cycle. With the multitude of LSPs in the logistics industry [1, 4, 5] with their inherent multitude of provided services the catalog-function is emphasized once again. Another important aspect for a SM and the (potential) relations between the contained services are permission and refusal of particular service interrelations. The European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) [16] outlines a big quantity of self-explanatory examples for this fact.

3 Related Work

In the following section we discuss yet existing metamodel and SM approaches concerning their influence towards the parts of the LSEM-platform. After emphasizing the need for an appropriate metamodel, we outline approaches from current literature. The metamodeling section below provides examples of already present approaches which either have influence on or which are close to concepts of our approach. The service map section discusses the complex situation of the topic, found during literature studies.

3.1 Metamodeling

Atkinson and Kühne emphasize important requirements of model-driven development in [17] and thus, outline the capabilities of metamodeling. The most important capabilities in our context are the following, as they take on great significance especially in the context of logistics. Metamodeling approaches increase the long-term productivity of primary software artifacts by reducing their sensitivity to changes. Those changes (and the resulting benefits of metamodeling in parenthesis) could be located in the fields of personnel (ease of understanding by different stakeholders) and functional requirements (integrating new features and capabilities with low maintainance and without disruption) and in development and deployment platforms (decoupling artifacts from tools with the inherent interoperability). However, issues may arise in this context: Dealing with models and metamodels may lead to multiple versions which are maintained independently and in the worst case lead to inconsistencies. To avoid such problems specialized platforms, so called metamodel-platforms, help to increase productivity when dealing with metamodeling issues. They offer the ability to manage metamodels and accordant versions of conformant models and in that they also allow versioning. The approach of [18] presents a metamodeling platform based on a model hierarchy and is explicitly dealing with modeling methods and their essential components like a modeling language, its notation, syntax and semantics, which in turn are also relevant for designing and implementing a service repository. The approach of [19] deals with modeling enterprise architecture with a layered strategy and therefore develops multiple, layer-specific metamodels and integrates them into a common model.

As the logistics integrator cooperates with a large number of LSPs and customers (personnel aspects), with a changing range of offered services and customer demands (functional requirements) and a widespread range of IT-systems (platforms), a metamodel hence, is an important artifact for tools that are integrated on the LSEM-platform. Accordingly, the logistics SM is obliged to own an appropriate metamodel itself. In [15] a metamodel for the integration and transformation of differing models has already been presented, yet. Its characteristics are compulsory to all integrated metamodels and subsequently to the SM-metamodel.

3.2 Related Service Map Concepts

When dealing with the topic of service maps, three characteristics can be described. (a) The term 'service map' is used and also the perception of functionality contains points of contact to our understanding of a SM, e.g. [20, 21, 22, 23]. (b) The term 'service map' is used, but a different contextual understanding is given, e.g. [24]. (c) The term 'service map' is not used explicitly, but the described concept contains notions similar to our context, e.g. [25].

Approaches of (a) are located in various fields. [20] provides the understanding closest to our context. The SM is used in the financial industry to get an overview of current portfolios to support merging and outsourcing of business models and IT-systems. Service retrieval and the creation of atomic or tailored customer-focused composite services is not an issue. [21] use a user-centric SM to visualize mobile apps within a 'user needs' categorization in order to identify 'empty' spaces with unsatisfied needs as potential service innovation opportunities. [22] propose a XML-based notion to enhance service structuring by establishing association and combination operators via XML-tags. [23] introduce a mobile data management approach. With obtaining a detailed view of available networks and their inherent capabilities, attributes and offered services in the surrounding of a mobile device. However, their categorization pattern is strongly spatial-based, but also a comprehensive overview of available services is given from which the customer could choose its preference for specific purpose. The case (b) [24] addresses a mapping or matching, respectively, of Quality of Service (QoS)-classes. The approach deals with data quality in heterogeneous networks consisting of several network technologies. The goal is a mapping of performance parameters of the different technologies. The concept of (c), the 'service portfolio management framework' [25] combines both service science and portfolio management. Therefore, its purpose tends to a strategic understanding of service management rather than providing a modular construction system to integrate a number of subcontractors.

4 The Service Map Metamodel

The analysis of the parts of the LSEM-platform and the related work revealed the need for developing a metamodel for the logistics SM that considers the criteria outlined in section 2 and 3. This section now focuses the development of a metamodel for the logistics SM.

4.1 Conceptual Design

The SM supports the categorizing and development of services. Instances of the SM can be derived by the integrator from the metamodel to describe specific service portfolios of a network. The advantage of a metamodeling approach is a high abstraction that provides a high reusability in a wide range of cases and a simple interaction between several instances. To ensure compatibility to our research framework, the SM metamodel follows the same restrictions of SMF like all other models (i.e. based on the EMOF (Essential Meta Object Facility) compatible Ecore[1] metametamodel of the Eclipse Foundation). Having all models defined with the same modeling language on metamodel-level, we are able to reuse information contained in these models. Thus, the SM metamodel is also defined in Ecore, but could be easily implemented in other frameworks as well. The metamodel does not raise claim to completeness and is adaptable. The following metamodel is situated on the M^2-level, whereas M^0 is the original SM (i.e. service catalog and construction system) and M^1 designates a model of the SM (e.g. Fig. 2).

Fig. 3 depicts the current version of the SM metamodel. Each instance consists of exactly one *catalog* containing services available to the integrator on the platform. This catalog is structured using *categories* which depend on a specific *domain* (e.g. logistics). Thus, the catalog represents a structured list of *services*, each capable of one or more *capabilities*. These capabilities belong to a specific

[1] http://www.eclipse.org/modeling/emf/?project=emf

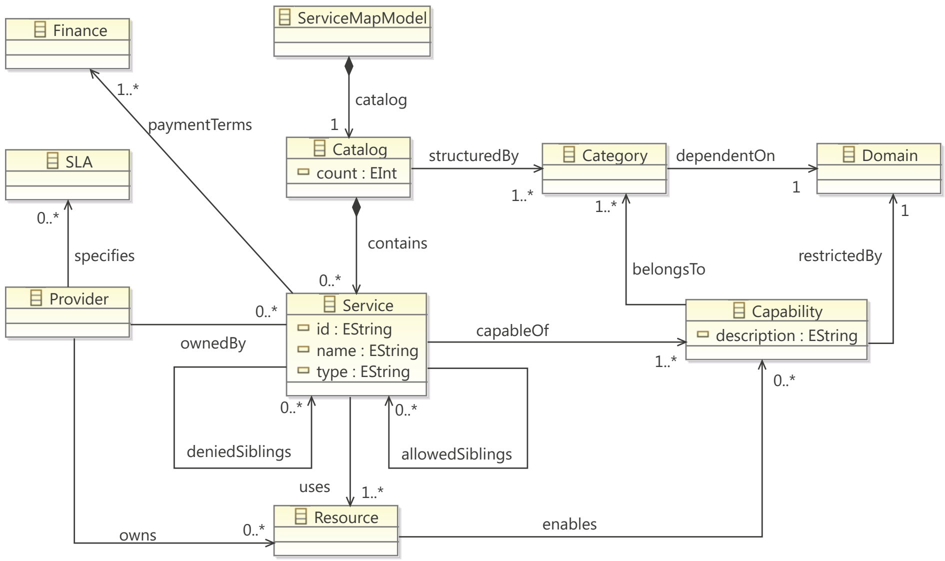

Fig. 3. Ecore model version of SM metamodel

category and are restricted by the concrete domain. For instance, on a high level capabilities represent the ability to transport, store or to fulfill more complex composite and value adding services. In order to provide capabilities in terms of services, a *provider* owns specific *resources* like trucks or warehouses which are consumed during service execution but typically are available again afterwards. Each provider is also allowed to specify zero or more *service level agreements (SLA)* for its services in which it specifies constraints of service provisioning and terms of payment. Finally, services can either depend on other services or are restricted not to work with other services. Therefore, each service contains references to others which are either available for the definition of a composed service (*allowedSiblings*)or not (*deniedSiblings*).

An instance of a logistics SM thus represents a complete list of capabilities (represented by services) of the provider network, including services the integrator can provide on its own. Hence, the service map serves as a catalog of available services. Moreover, during the creation of a complete logistics service for a customer, the service map also serves as a unique point of information and as a reference for searching appropriate services and providers. This becomes apparent in the development phase in particular. During rough planning of a logistics service, the service chain has to be constructed by choosing suitable services. According to customers' requirements, appropriate providers have to be chosen for each task in the service chain. Therefore, the service map is used to identify providers who offer the needed service type.

Because the logistics SM follows a metamodel-based approach, an integrator also has the ability to manage multiple provider networks independently, for instance in automotive industry. Requirements of OEMs (Original Equipment

Manufacturer) are very strict in that they often demand closed supply chains. Providers are not allowed to share their resources between different contracts. For instance, an integrator responsible for warehouses with vendor managed inventory (VMI) for multiple OEMs at nearby production sites is liable to provide warehouse resources to each of the OEM exclusively, i.e. separate infrastructure and employees. With this in mind, an integrator is still able to optimally allocate resources if he partitions its complete network into independent parts and manages each of them separately. Though, same services are in different catalogs, the integrator is aware of the total resources available and can create an efficient supply chain for each customer.

4.2 Discussion

The integration of interfaces as an aspect of the SM metamodel was roughly discussed during design process. However, it forms a relevant notion, but we decided to leave the topic out in the current version. Due to the CSM-functionality of the repository (see 2.2), interweaving with other models and tools is granted. Further a capability-centered approach was considered. When building composite services and supply chains, the inherent service function or capability is the important object for the integrator or planer, respectively, as these functions realize the actual flow of goods and information. On the contrary, the SOA design-paradigm always focuses on the services themselves. Hence, with the service class as the obligatory central component of every model and metamodel, respectively, the service is put in the focus of attention. Consequently a unique connection point is ensured in every case and every part of the architecture and the related model-driven approaches. However, the developed metamodel derives its structure and content from the example-domain of logistics, but excludes logistics-specific aspects by incorporating them in an abstract way. Through including a certain domain as a crucial foundation of a SM, the presented approach is also usable in other fields of service-oriented industries.

5 Summary

In this paper we presented an approach for metamodel-based service map to be used in logistics. In contrast to [11] important concepts and used technologies of the logistics SM have been developed and are more elaborate. The approach is designed to the needs of the LSEM-platform and is compatible to other tools and concepts. Most important, the logistics SM is able to fill the gap of categorizing, structuring and identifying available services on the platform and hence is essential in the early phases of the service life-cycle. We initially presented contraints and related tools of the platform like the service repository and proceeded with basic principles a service map is developed for. We also localized this approach in the logistics domain and could thus tailor the service map to the specific needs of a logistics integrator. Nevertheless, the approach is also applicable in other service-oriented industries.

Acknowledgement. The work presented in this paper was funded by the German Federal Ministry of Education and Research under the project LSEM (BMBF 03IPT504X).

References

[1] Gudehus, T., Kotzab, H. (eds.): Comprehensive Logistics. Springer, Heidelberg (2012)

[2] Schmitt, A.: 4PL-Providing™ als strategische Option für Kontraktlogistikdienstleister: Eine konzeptionell-empirische Betrachtung. Deutscher Universitäts-Verlag / GWV Fachverlage GmbH, Wiesbaden (2006)

[3] Kutlu, S.: Fourth party logistics: The future of supply chain outsourcing? Best Global Publishing, Brentwood (2007)

[4] Handfield, R., Straube, F., Pfohl, H.C., Wieland, A.: Trends and Strategies in Logistics and Supply Chain Management: Embracing global logistics complexity to drive market advantage. Trends and strategies in logistics and supply chain management. DVV Media Group, Hamburg (2013)

[5] Terry, L.: 2014 third-party logistics study: The state of logistics outsourcing: Results and findings of the 18th annual study (2014)

[6] Klinkmüller, C., Kunkel, R., Ludwig, A., Franczyk, B.: The logistics service engineering and management platform: Features, architecture and implementation. In: Abramowicz, W. (ed.) BIS 2011. LNBIP, vol. 87, pp. 242–253. Springer, Heidelberg (2011)

[7] Erl, T.: SOA: Principles of service design. Prentice Hall, Upper Saddle River (2008)

[8] Papazoglou, M.: Web services: Principles and technology. Pearson/Prentice Hall, Harlow (2008)

[9] Beverungen, D., Knackstedt, R., Müller, O.: Entwicklung serviceorientierter architekturen zur integration von produktion und dienstleistung – eine konzeptionsmethode und ihre anwendung am beispiel des recyclings elektronischer geräte. Wirtschaftsinformatik 50(3), 220–234 (2008)

[10] Acharya, M., et al.: Soa in the real world – experiences. In: Benatallah, B., Casati, F., Traverso, P. (eds.) ICSOC 2005. LNCS, vol. 3826, pp. 437–449. Springer, Heidelberg (2005)

[11] Glöckner, M., Ludwig, A.: Towards a logistics service map: Support for logistics service engineering and management. In: Blecker, T. (ed.) Pioneering Solutions in Supply Chain Performance Management: Proceedings of the Hamburg International Conference of Logistics (HICL) 2013, Eul, Lohmar, Köln. Reihe: Supply chain, logistics and operations management, vol. 17, pp. 273–285 (2013)

[12] Papazoglou, M.P., Van Den Heuvel, W.-J.: Service-oriented design and development methodology. International Journal of Web Engineering and Technology 2(4), 412 (2006)

[13] Blake, M.B.: Decomposing composition: Service-oriented software engineers. IEEE Software 24(6), 68–77 (2007)

[14] Gu, Q., Lago, P.: A stakeholder-driven service life cycle model for soa. In: Crnkovic, I. (ed.) 2nd International Workshop on Service Oriented Software Engineering: in Conjunction with the 6th ESEC/FSE Joint Meeting, pp. 1–7 (2007)

[15] Augenstein, C., Ludwig, A., Franczyk, B.: Integration of service models - preliminary results for consistent logistics service management. In: 2012 Annual SRII Global Conference, pp. 100–109. IEEE Computer Society, Los Alamitos and Calif (2012)

[16] United Nations: ADR - European Agreement Concerning the International Carriage of Dangerous Goods by Road: Applicable as from 1 January 2013. United Nations, New York (etc.) (2012)
[17] Atkinson, C., Kühne, T.: Model-driven development: a metamodeling foundation. IEEE Software 20(5), 36–41 (2003)
[18] Karagiannis, D., Kühn, H.: Metamodelling Platforms, vol. 2455, pp. 451–464. Springer, Heidelberg (2002)
[19] Braun, C., Winter, R.: A comprehensive enterprise architecture metamodel and its implementation using a metamodeling platform. In: Enterprise Modelling and Information Systems Architectures, vol. P-75, pp. 64–79. GI (2005)
[20] Kohlmann, F., Alt, R.: Aligning service maps - a methodological approach from the financial industry. In: Sprague, R.H. (ed.) Proceedings of the 42nd Annual Hawaii International Conference on System Sciences, pp. 1–10. IEEE Computer Society Press, Los Alamitos (2009)
[21] Kim, J., Lee, S., Park, Y.: User-centric service map for identifying new service opportunities from potential needs: A case of app store applications. Creativity and Innovation Management 22(3), 241–264 (2013)
[22] Vaddi, S., Mohanty, H., Shyamasundar, R.: Service maps in xml. In: Potdar, V. (ed.) Proceedings of the CUBE International Information Technology Conference, pp. 635–640. ACM, [S.l.] (2012)
[23] Kutscher, D., Ott, J.: Service maps for heterogeneous network environments. In: MDM 2006, Japan. IEEE Computer Society, Los Alamitos (2006)
[24] Ryu, M.S., Park, H.-S., Shin, S.-C.: Qos class mapping over heterogeneous networks using application service map. In: Networking, International Conference on Systems and International Conference on Mobile Communications and Learning Technologies, vol. 13. ICN (2006)
[25] Kohlborn, T., Fielt, E., Korthaus, A., Rosemann, M.: Towards a service portfolio management framework. In: Australian Conference on Information Systems, ACIS2009, pp. 861–870 (2009)

4.2 Executive Summary

The paper contains the conceptual basis of the *map* that facilitates the management of cloud logistics service. With the help of a literature review, the field of mapping, categorizing, and retrieving services is analyzed, conceptualized, and a conceptual basis is developed. With the approach of metamodeling, a concept is derived that can be applied to a wide range of logistics networks. The analytical method is a literature review. The design approach is based on the methods of conceptual modeling [Goos et al., 1999] and metamodeling [Atkinson and Kühne, 2003]. The paper answers RQ_3 (see Section 1.2).

The conceptualization of the management concept *logistics service map* comprises the development of an approach for structuring, presenting and retrieval of logistics services. The paper develops a metamodel for such a service map by analyzing requirements from functional aspects of the general service map approach, and domain-specific aspects. The metamodel sets restrictions of the service map models in terms of one catalog that contains all available services. This catalog is structured by categories. Services comprise one or more capabilities and are offered by a (logistics service) provider and operated based on certain resources. Another important feature is the restriction of services not to work with or to depend on other services. Especially, in the logistics domain special conditions, such as the handling and transport of hazardous material, imply a number of restrictions, certifcation and thus a rigorous seperation of certain resources or goods. The metamodel is presented in Figure 4.1

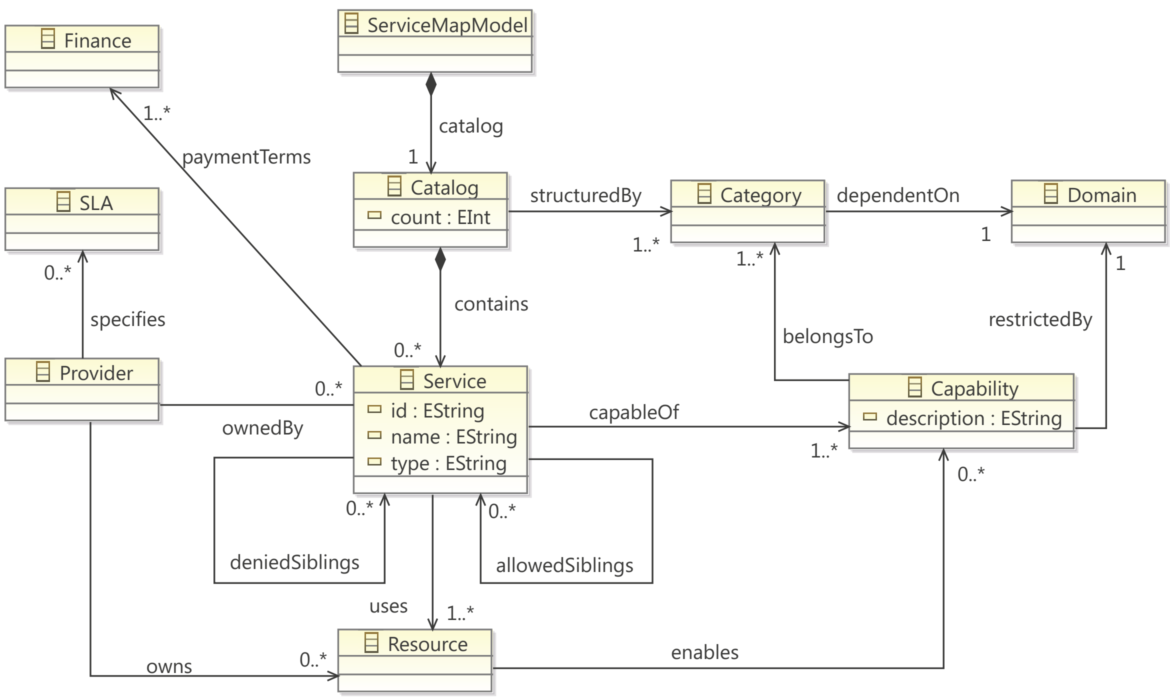

Figure 4.1: Ecore model version of the map's conceptual metamodel.

In terms of contribution type level (see Table 1.2) and the kind of knowledge contribution (see Table 1.9), the artifact of the paper can be characterized as follows:

The developed metamodel is based on the well-known metamodeling approach. The solution is adopted to the field of collaborative logistics and thus, the artifact is an exaptation. The metamodel can be used in order to derive model instances for different purposes and parts of logistics networks. Hence, the artifact is applicable to a range of problems and thus is located on the second level.

This paper lays the foundation for the management of cloud logistics service description ("service map") and is complemented technically by the artifact of paper #4. The results are further used for the service granularity framework (#5), and transitively for the prototype (#6), the application example (#7), as well as the consolidation and research roadmap (#8).

5 Map - Technical

Glöckner, Michael; Ludwig, André (2017): Ontological Structuring of Logistics Services. In: Ngonga, Axel; Sheth, Amit; Wang, yin; Chang, Elizabeth; Ślęzak, Dominik; Franczyk, Bogdan; et al. (Ed.) Proceedings of the International Conference on Web Intelligence, WI 2017, Leipzig, Germany, August 23-26, 2017. Pp 146-153. [Glöckner and Ludwig, 2017c]

5.1 "Ontological Structuring of Logistics Services"

Table 5.1: Meta data of the publication (Map - Technical).

DOI	10.1145/3106426.3106538
URL	https://dl.acm.org/citation.cfm?id=3106538
Type	Conference Paper, Proceedings
Publication in	Proceedings of the International Conference on Web Intelligence (WI-IAT) 2017
Editor	Ngonga, Axel; Sheth, Amit; Wang, yin; Chang, Elizabeth; Ślęzak, Dominik; Franczyk, Bogdan; et al.
Series Title	Proceedings of the International Conference on Web Intelligence
ISSN / ISBN	978-1-4503-4951-2 (ISBN)
Publisher	ACM
Place of Publication	Leipzig, Germany (WI 2017); New York, NY, USA (Proceedings)
Ranking	CORE: B-ranked (conference) VHB: - h-index: -

A short version of the paper was also presented at the WOP workshop at the International Semantic Web Conference (ISWC 2017), held in Vienna, Austria. Reference: Glöckner, Michael; Ludwig, André (2017): LoSeMa ODP - An Ontology Design Pattern for Logistics Service Maps. In: Blomqvist, Eva; Corcho, Oscar; Horridge, Matthew; Hoekstra, Rinke; Carral, David (Ed.) Post-Workshop Proceedings of the Workshop on Ontology and Semantic Web Patterns @ International Semantic Web Conference, ISWC 2017, Vienna, Austria, October 21-25, 2017. [Glöckner and Ludwig, 2017b], http://ontologydesignpatterns.org/wiki/images/a/a0/Paper-10.pdf.

The publishing of ODP through the 'official' community is bound to the annual *Workshop on Ontology and Semantic Web Patterns* (WOP): http://ontologydesignpatterns.org/wiki/WOP:Main

Ontological Structuring of Logistics Services

Michael Glöckner
Leipzig University
Endowed Chair of Logistics Information Systems
Leipzig, Germany
gloeckner@wifa.uni-leipzig.de

André Ludwig
Kühne Logistics University
Chair of Computer Science in Logistics
Hamburg, Germany
andre.ludwig@the-klu.org

ABSTRACT

The paradigm of cloud logistics is essentially built upon the virtualization of logistics resources from different logistics service providers. The virtualized resources are pooled and can subsequently be combined and encapsulated within customer-specific modular logistics services. The pooling within bigger logistics networks leads to a high quantity of different available logistics resources and services. Domain-specific structuring with the concept of the logistics service map helps to retrieve specific requested services from that quantity. The structuring of resources and services is a challenging task based on the semantic gap of differing wordings, descriptions used by different providers. The developed ontology design pattern for domain-specific structuring of logistics services can help to close the semantic gap as well as to enable the concept of the logistics service map. Structuring data and information (of services) from different providers can be made available, linked and interchanged easily within the network. Digitalized collaboration is supported and the disruptive paradigm of cloud logistics is enabled.

KEYWORDS

ontology design pattern, logistics, service map, domain structuring, cloud logistics

ACM Reference format:
Michael Glöckner and André Ludwig. 2017. Ontological Structuring of Logistics Services. In *Proceedings of WI '17, Leipzig, Germany, August 23–26, 2017,* 8 pages.
https://doi.org/10.1145/3106426.3106538

1 INTRODUCTION

The disruptive paradigm of *Cloud Logistics* [7, 16, 19] is based on the virtualization and pooling of physical and non-physical logistics resources from different logistics service providers (LSP). According to customer-specific demand, resources are taken from the pool, are combined with each other and encapsulated within modular cloud logistics services. This modular approach enables the logistics industry to face the continuous trends of outsourcing and concentration on core competencies [22, 41] in order to meet customers' demand for increased flexibility [9, 40]. Further, digitalization of logistics, as an enabler in the context of the Internet of Things [21], is pushed forward. The most difficult challenge of connecting different LSP is the semantic gap because of different structuring, naming, descriptions and IT-systems that results from a strong heterogeneity of LSP [11, 31, 36]. Cloud logistics adopts the basic principles of cloud computing, i.e. resource virtualization, ad-hoc reconfiguration, and interconnect-ability, via an ontological approach [16] in order to handle the heterogeneity.

One central challenge of cloud logistics is the management of the large amounts of logistics services available in big networks. This comprises on the one hand the retrieval of suitable resources and services from several LSP that are participating in the network. On the other hand, it comprises the customer-oriented combination of the resources and services from several LSP in order to create complex logistics services. The Logistics Service Map [14] is a conceptual framework for domain-driven structuring of services as well as their retrieval and combination in order to create complex logistics services. However, the semantic gap between different LSP exists also for the structuring of resources and services. Hence, an ontological approach for service structuring is needed to close the semantic gap in order to facilitate management and retrieval. However, different networks and different industries (e.g. automotive, chemistry) have different logistics requirements and descriptions. The structuring of cloud logistics services is dependent on semantic building blocks, so called ontology design patterns (ODP) [12, 35], that enable the structuring of resources from different LSP. An ODP represents the elementary trunk of a generic ontology for a specific purpose. It has to be extended for actual usage but gives essental guidance for the creation and usage of an ontology in that specific field of purpose. Next to logical or architectural ones, there are content ODP (CP) [35] that encode conceptual pattern solving design problems for domain-related classes and properties. In summary, a reusable (CP) for the structuring of logistics services is needed. Such a CP further supports the aspects described in cloud logistics paradigm, i.e. the pooling, encapsulation and combination of logistics resources from several LSP. The research question arises: *How can essential structurings of logistics services be represented in an ontology design pattern?* It is refined through the following sub-questions:

- SQ_1: What are existing logistics ontologies and what are essential structuring concepts of logistics services that could be re-used?
- SQ_2: What is a suitable ontology design pattern for the structuring of logistics services?

In the course of the paper the 'NeOn Methodology for Ontology Engineering' [42] is applied and complemented with the approach

WI '17, August 23–26, 2017, Leipzig, Germany

ACM ISBN 978-1-4503-4951-2/17/08…$15.00
https://doi.org/10.1145/3106426.3106538

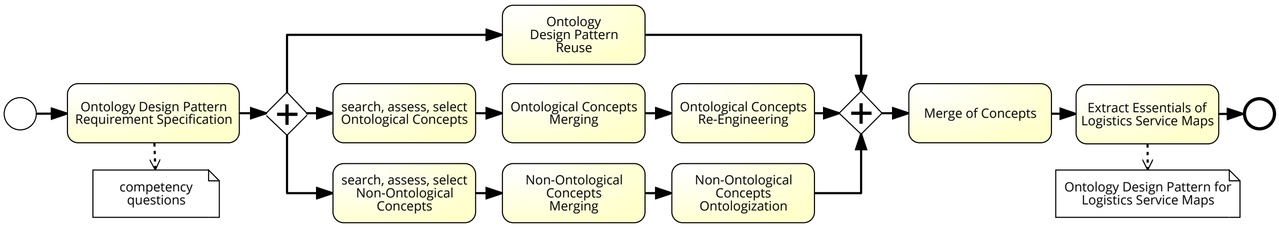

Figure 1: The method combines the NeOn methodology [42] and the combined approach for definition of ODP [35].

of ODP definition [35], see Figure 1. In section 2, competency questions are presented in order to specify requirements. Afterward, concepts are searched, assessed and selected. Those concepts can be found in existing ODP, existing logistics ontologies' concepts and non-ontological concepts of the logistics domain. By merging those concepts and extracting the essential aspects of logistics service structuring, the final ODP is developed. The ODP for logistics service maps is conceptualized, formalized, graphically represented and evaluated with the help of applied service structurings from real world use cases. Further, sample queries are given by the former competency questions. Section 3 concludes the paper and gives an outlook on future research.

2 THE LOSEMA PATTERN

In the following subsections general modeling issues, the competency questions as well as the regarded concepts are presented. Afterward, the concepts are merged, visualized as well as informally and formally described and evaluated.

2.1 Ontological Modeling of the Logistics Domain's Structuring

The logistics domain has only received little attention from the semantic web community yet. In literature there are some approaches of ontologies that deal with logistics topics. ODP in the context of logistics and SCM in general are not existent until 2014 [39]. However, only one of them can be considered as linked data in terms of the W3C-standard[1] as there are machine-readable XML files and URI (Unified Resource Identifier), i.e. the ontology design pattern on logistics service (LoSe_ODP) [15]. The other ontologies are only available in schematic and/or graphic way. The existing ontologies are customized and thus they cannot be re-used due to their proprietary formats. Accordingly, they are neither standardized nor inter-linkable. Further, conceptual overlaps can be found, which also means there are concepts that are frequently reappearing in the ontologies so far. Eventually, this paper presents the first approach towards linked data representation of logistics service maps by bringing together concepts of existing ontologies and domain-specific aspects of logistics service structuring within one ODP.

Competency Questions are leading the development of the pattern and are partly inspired by [15, 20, 38]. Their purpose is to give potential users of the ODP an idea of the field and issues that can be approached with the help of the ODP [35, 42]. Further, they can be taken to evaluate the developed ODP in the end:

- CQ_1: Which services enable the transport of dangerous goods on rail in southern Europe?
- CQ_2: Which value-added services are available in Denmark?
- CQ_3: Which value-added services are not available (and thus point out new business opportunities)?
- CQ_4: Where are hubs for gas handling with tanks and ship loading possibility?
- CQ_5: Where are inter-modal hubs in Germany for open sea to rail transshipment?
- CQ_6: Which services offer inbound and block storage for packaged goods?

Related ODP which has already been published and that will be reused is the existing *LoSe_ODP*[2] [15].

Re-Used Ontological Concepts are mainly taken from the literature review on *existing ontologies* of Scheuermann and Leukel [39] in the context of logistics (and supply chain management). They found a total of 16 ontologies. Via further research, another 14 paper were found presenting ontologies of logistics or supply chain management (or parts of it). Those ontologies were analyzed towards possible contributions to a logistics service map ODP. Unexpectedly, the majority of the analyzed concepts only focused on services concerning physical goods and objects. Accordingly, information-centric services in logistics, such as inventory optimization, consulting, or network strategy development, are under-represented. The adopted classes and properties of the influencing ontologies are conceptualized and briefly described in the following list:

- Domain-driven structuring focuses on (1) *character* of the logistics function of a service, i.e. either *informational* or *physical* [2, 15, 20, 28]; (2) on special *condition* implying legal permissions or special equipment for operation [6, 13]; and (3) further *dimensions* that describe the physical characteristics more detailed [2, 5, 6, 20, 25, 26]
- Within the class of special *condition* the idea of integrating an ontology or another ODP, respectively, on hazardous goods is taken from [38]. Further, as stated in [6], *Cooling*, *Living*, *Guarded*, and *HeavyDuty* are further special conditions that either require special legal permission and/or special equipment or skills to be operated

[1] https://www.w3.org/standards/semanticweb/data

[2] https://github.com/Michael-Gloeckner/LoSe_ODP/blob/master/LoSe_ODP.owl

- The physical functionality of logistics services is regularly distinguished between 'classic' function, such as *Transportation*, *Handling*, and *Storage* on the on side [2, 8, 20, 25, 26, 38]. On the other side, classic functions are more and more complemented in terms of more specialized, more complex and customer-oriented *Value-Added* functions, such as *Packing*, *Sorting*, and *SpecialServices* are outlined [6, 20, 25, 26].
- The informational functionality of logistics services comprise (1) *ProcessRelated* functionality with a rather operational focus, such as inventory management or track and trace [6]. There are also functionality with a more strategic focus, such as network strategy and inventory policy like Just-in-Time (JIT) [2, 4]. Further, (2) *Knowledge* intensive functionality is outlined such as transport flow improvement, consulting, reorganisation of network strategy, inventory modeling, research and development [2].
- The *StateOfGoods* plays an important role especially for the transport, handling, and storage. Possible classes for distinction are: *Packaged*, *Solid* (e.g. Bulk Goods), *Liquid*, and *Gas* [6, 33].
- The Supply-Chain operations reference (SCOR) model[3] developed by the 'supply chain council' is often the theoretical foundation for structuring of logistics services, e.g. see [10, 17, 23, 27, 32, 37**?**]. However, recent publications [15, 16, 24] found a lack of suitability of the SCOR model in terms of applicability on detailed and rather fine-granular logistics services. Hence, a rather logistics-focused and simplified view is adapted from SCOR in terms of *PhasesOfProcess*, i.e. *Production*, *Outbound*, *Transport*, and *Inbound*, are derived to be integrated in the ODP [20, 25].
- The *ModeOfTransport* is an important structuring dimension as it influences the means of transport, physical resources, handling devices, infrastructure and used interfaces. Hence, *Land*, *Sea*, *Air*, and even *Pipe* as a mode of transport for gas or liquids are mentioned [25, 26].
- *Location* as a crucial dimension of logistics servcies is emphasized by [2, 6, 8, 13, 25, 38].
- As time plays a more or less crucial role in all logistics activities [6, 44], an additional dimension in terms of *Speed* can be derived to distinguish *Express*, such as KEP Service Providers' services from services with *Normal* speed [20].

Non-Ontological domain-specific Concepts are taken into account in order to complement the found classes and properties of the re-used ontological concepts. This comprises other data models and logistics concepts, e.g. generally accepted structuring frameworks and essential logistics characteristics, in order to create the logistics service map ODP. Additional ValueAdded service structurings are taken from one of the biggest annual studies amongst 3rd Party Logistics Providers [22]. ValueAdded services are in general more complex than just handling and transportation functionality. They have higher informational requirements as additional information is needed for fulfillment and thus deserve an own structuring subclass of physical logistics functions. Those value-added services with a strong focus on physical operation are e.g. *Labeling*, *Packaging*, *Assembly*, and *Kitting* [22]. Further, other informational focused structurings that specify ProcessRelated structurings more detailed are e.g. *Customs Brokerage* and *CustomsService*, *TransportationManagementAndPlanning*, *FreightBillAuditingAndPayment*, *FleetManagement*, *ITServices* [22]. The ModeOfTransport can be further refined for land-bound means of transport into *Road* and *Rail* as well as for sea-bound means of transport into *OpenSeaShipping* and *InlandShipping*, see Ref [18] and further statistics[4]. For the structuring of storage services *StorageType* as well as *StorageStrategy* are important criteria in order to find appropriate services [18]. Whereby, different types of storage are warehouses and facilities for e.g. *Bulk*, *Block*, *HighRack*, or *Tank* for gas or liquid goods. Storage strategy has three main principles for distinction, i.e. chaotic or fixed for the *Allocation* of goods within the warehouse and the chronology and *Sequence* of handling, i.e. first in - first out (FIFO) or last in - first out (LIFO), and eventually strategies for *SafetyStock* and replenishment [18]. Further, *legal constraints* are important to the logistics domain, e.g. permission to handle dangerous goods [1]. The analyzed ontological and non-ontological concepts of the logistics domain form the basis for the essential concepts for the structuring of logistics services within the logistics service map and answer the second sub-question (SQ_1).

2.2 Merging the Concepts into the Pattern of LogisticsServiceMaps - LoSeMa_ODP

The several concepts are analyzed and the essentials of structuring the logistics domain, especially logistics services, are integrated into the ODP for logistics service maps[5]. The schematic view can be seen in Figure 2. The pattern is formalized with OWL 2 Web Ontology Language (OWL) [30] and modeled with the tool Protégé[6] and expressed further detailed in description logic [3].

Focus and top-level class of the current paper is LogisticsServiceMap. By linking the ODP to other ODPs, its full potential can be utilized. The pattern of LogisticsService (light blue) is described in the *LoSe_ODP*[7] [15]. This pattern describes logistics services in terms of their essential flows, capabilities as well as the consumed resources for their operation. The link to an ODP concerning *hazardous materials and goods* enables the detailed description and requirement of specialized resources for handling, transport and storage as well as the requirement for legal permissions and internationally authorized structuring scheme. The link to *GeoArea* ODP, which deal with the allocation, relation and semantic description of geographic concepts such as cities, regions, countries, and continents, helps to narrow down results of service retrieval for a specific area. The extension with zipcodes and street names could further increase the level detail.

Roughly described, logistics services are structured by the logistics service map by three main concepts, i.e. (1) *Condition* of goods and customer requirements, (2) functional *Character*, and (3) *Dimension*. Additional sub-concepts, see Figure 2 and the former subsection, allow for an even more detailed structuring with the

[3] http://www.apics.org/apics-for-business

[4] http://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2015_en

[5] https://github.com/Michael-Gloeckner/LoSeMa_ODP

[6] Protégé is the ontology building software used for LoSeMa_ODP. For more detail see: http://protege.stanford.edu/.

[7] https://github.com/Michael-Gloeckner/LoSe_ODP/blob/master/LoSe_ODP.owl

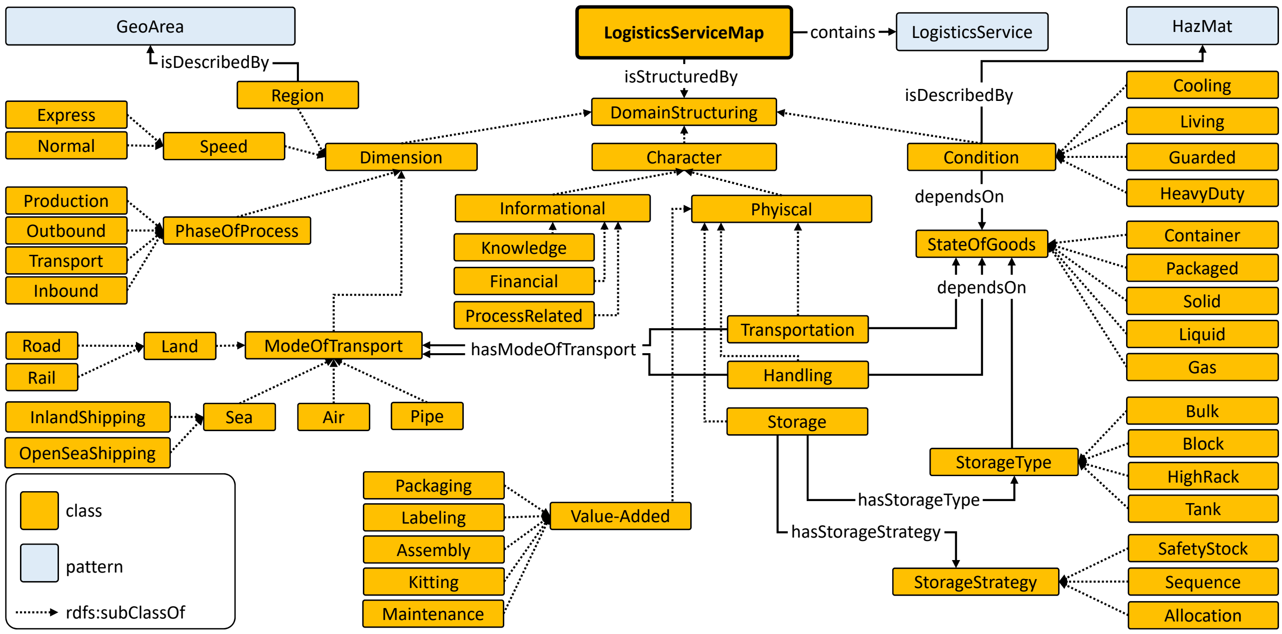

Figure 2: Schematic view of the ontology design pattern for logistics service maps.

help of several subClasses (rdfs:subSclassOf). The *StateOfGoods* is an important class as it influences the *Condition* of logistics services, and all the three classic physical logistics services: *Transportation*, *Handling* (both directly) as well as *Storage* via the *StorageType*. The implemented *StorageStrategy* can also be important structuring criteria e.g. because of a higher informational requirement on chaotic storage. Examples for informational logistics services are as follows; *ProcessRelated* services could be: customs clearance, invoicing, incoterms broking and operative management, track and trance, warehouse management, as well as transport management. *Knowledge* services could be: consulting, training, IT management as well as research&development. Examples of *Financial* logistics services could be: real estate brokerage and management, insurance, leasing, strategic incoterms management or strategic fleet management.

Several axioms are developed in order to facilitate the implementation of the pattern in practical application and use cases. Physical *Transportation* always requires at least one possible *ModeOfTransport* (Axiom 1). Physical *Handling* of goods requires 2 ModeOfTransport in terms of a source and a sink from where goods are handled to (Axiom 2). Every *Physical* logistics service needs to state at least one *StateOfGoods* it is capable of serving (Axiom 3). *Informational* services focus on data and *Physical* services focus on the operation of goods. Hence, they have to be clearly distinct from each other (Axiom 4).

$$\text{Transportation} \sqsubseteq \; \geqslant 1\ \text{hasModeOfTransport.ModeOfTransport} \tag{1}$$

$$\text{Handling} \sqsubseteq \; \geqslant 2\ \text{hasModeOfTransport.ModeOfTransport} \tag{2}$$

$$\text{Physical} \sqsubseteq \; \geqslant 1\ \text{dependsOn.StateOfGoods} \tag{3}$$

$$\text{Informational} \equiv \neg\text{Physical} \tag{4}$$

The presented ODP[8] is derived from existing concepts of the logistics domain and is able to structure logistics services within the concept of the logistics service map. Thus, SQ_2 is answered.

2.3 Evaluation

The 'Framework for Evaluation in Design Science Research' (FEDS) developed by Venable et al. [43] is used for evaluation. The designed ODP is of small and simple construction, with low social and technical risk and uncertainty. Hence, the *quick & simple* strategy is chosen for evaluation as it appears to be relatively cheap to use public available data of the analyzed companies. The developed ODP wil be evaluated by an *illustrative scenario* [34]. The evaluation is summative (judge the extent that the outcomes match expectations) and located in the middle between artificial and naturalistic: two applied service structuring approaches form the use cases for evaluation. First, the overview and structuring of services that are available in the *Port of Hamburg*, which is the largest sea port in Germany and the third largest in Europe[9], are taken into account. Further, the Servcie catalogue of *DB Cargo* is the second use case for evaluation. DB Cargo is the rail-focused business segment of DB Schenker that in turn appears to be under the top 3 global logistics service providers[10]. The design goals of *flexibility* and *re-usability* [29] are taken into account for evaluation of the designed ODP, as they are the core ideas of cloud logistics [16] and strongly demanded by customers [9, 40]. The developed ODP is proved by representing the structurings of the two use cases.

[8] https://github.com/Michael-Gloeckner/LoSeMa_ODP/blob/master/LoSeMa_ODP.owl
[9] https://www.hafen-hamburg.de/en/statistics/top-20-container-ports
[10] http://www.3plogistics.com/3pl-market-info-resources/3pl-market-information/aas-top-50-global-third-party-logistics-providers-3pls-list/

Use Case 1 comprises Port of Hamburg's structuring of logistics services in the portal *"PORTlog - your virtual freight village"*[11] in order to find appropriate contacts for specific services as displayed in Figure 3. Analyzing the structuring displayed by the PORTlog portal, several parallels to the LoSeMa_ODP can be drawn. For instance, The 'Warehousing & Logistics' category of PORTlog comprises the structuring classes of *Transportation* and *Handling*. Similar to the ODP, several states of the operated goods (i.e. container, general cargo, and bulk) as well as special conditions (temperature controlled / cooling / , and dangerous cargo/hazardous materials) can be drawn in PORTlog.

Figure 3: Screenshot from online portal PORTlog.

For the evaluation, it is assumed that the structure of PORTlog is based on an internal ontology. With the help of ontological mapping to the LoSeMa_ODP, the structuring can be mapped and accordingly the services within the PORTlog can be retrieved and reasoned from other network participants as well via querying the LoSeMa_ODP. In OWL, mappings between ontologies and distinct classes of those ontologies are presented by the statement `owl:sameAs`. Additional parallels can be drawn and are displayed as an example in the associating OWL-statements that follow (for a better readability, they are presented in Turtle-Syntax):

```
@prefix LoSe_ODP:
<https://github.com/Michael-Gloeckner/LoSe_ODP#>
@prefix PORTlog:
<https://www.hafen-hamburg.de/en/portlog#>
LoSeMA_ODP:Transportation rdf:type owl:Class ;
        owl:sameAs PORTlog:Warehousing&Logistics .
LoSeMA_ODP:Handling rdf:type owl:Class ;
        owl:sameAs PORTlog:Warehousing&Logistics .
LoSeMA_ODP:Container rdf:type owl:Class ;
        owl:sameAs PORTlog:Container (Depot) .
LoSeMA_ODP:Handling rdf:type owl:Class ;
        owl:sameAs PORTlog:Container (CFS) .
LoSeMA_ODP:Cooling rdf:type owl:Class ;
        owl:sameAs PORTlog:Temperature controlled .
LoSeMA_ODP:HazMat rdf:type owl:Class ;
        owl:sameAs PORTlog:Dangerous Cargo .
LoSeMA_ODP:Knowlegde rdf:type owl:Class ;
        owl:sameAs PORTlog:Knowledge & Consulting .
```

As shown as an example, the LoSeMa_ODP is able to present and map the service structuring of the PORTlog use case. Further, it is the inherent nature of ODP as the elementary body of a generic ontology that it is extendible [12, 35]. Hence, even for specialized structuring categories, such as 'Marine Services' of PORTlog that is typical for sea ports, new classes can be added to the ODP in order to customize and develop it towards an applicable ontology.

Use Case 2 comprises DB Cargo's *"Service catalogue"*[12] as displayed in Figure 4. This Service catalogue structures and presents all available services of DB Cargo provided in Germany and Europe and thus all services are related to rail-bound freight transportation in a broader sense.

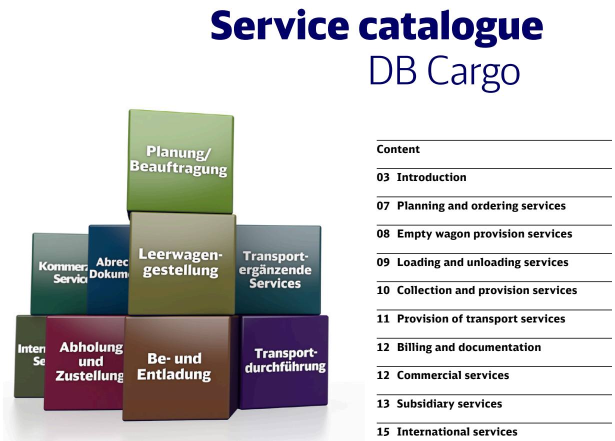

Figure 4: Screenshot of DB Cargo's Service catalogue.

Hence, the majority of the services can be linked to the LoSeMa classes of *Physical* and *Rail*. Parallels can be drawn for instance between the *Handling* class of LoSeMa and the category of 'Loading and unloading services' of DB Cargo's Service catalogue. Further, parallels exist between several provided services of the 'subsidiary' class of the catalogue, see Figure 5. The services 'Loading consultancy' and 'trial loading/initial loading' can be identified with the *Consulting* class of the LoSeMa. Moreover, the services 'Inspect load size' and 'regular wagon inspection and damage assessment in workshops' can be related to *ValueAdded* character. More specific, the latter one can be associated with *Maintenance*. As *Maintenance* is a sub class of *ValueAdded*, the linkage to the more specific one increases precision of retrieval. The service 'Impact testing' can be equaled to the class of *Knowledge* as it can be identified as a kind of research and knowledge creation. Eventually, 'dangerous and military goods' are equated with the HazMat pattern, whereas 'domain' denotes the origin and 'range' denotes the sink of an relating ObjectProperty. The 'Surveillance and accompanying' can be equated with either the *Guarded* class or the *TrackAndTrace* class of

[11] https://www.hafen-hamburg.de/en/portlog

[12] http://www.dbcargo.com/file/rail-deutschland-en/7946484/_2ZqlphcADXzoG0iKgHQY14Ciuw/8799380/data/Service_catalogue.pdf

the ODP. More detailed information about the content and context is necessary in order to assure an appropriate link.

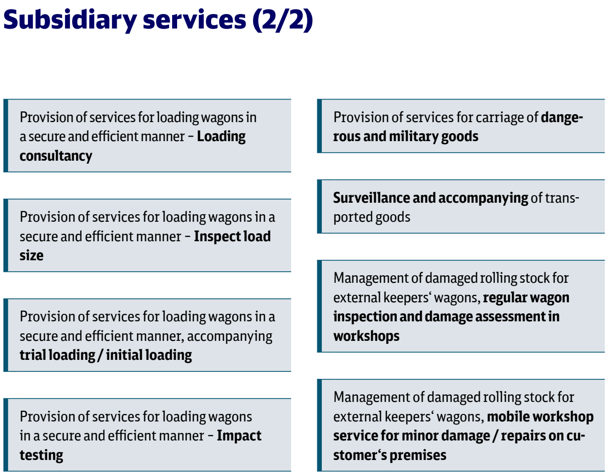

Figure 5: Screenshot of DB Cargo's subsidiary servcies.

Again, it is assumed that there is an underlying internal ontology existent for the Service catalogue of DB Cargo. Hence, again those structures can be mapped to the designed LoSeMa_ODP via OWL statements.

```
@prefix LoSe_ODP:
<https://github.com/Michael-Gloeckner/LoSe_ODP#>
@prefix DBCargo:
<http://www.dbcargo.com/rail-deutschland-en/products_
services/additional_services/Service_catalogue.html#>
LoSeMA_ODP:Handling rdf:type owl:Class ;
       owl:sameAs DBCargo:LoadingAndUnloading .
LoSeMA_ODP:Consulting rdf:type owl:Class ;
       owl:sameAs DBCargo:Loadingconsultancy ;
       owl:sameAs DBCargo:TrialLoading .
DBCargo:InspectLoadSize rdf:type owl:Class ;
       rdfs:subClassOf LoSeMA_ODP:ValueAdded .
DBCargo:RegularInspection rdf:type owl:Class ;
       rdfs:subClassOf LoSeMa_ODP:Maintenance .
DBCargo:ImpactTesting rdf:type owl:Class ;
      rdfs:subClassOf LoSeMa_ODP:ResearchDevelopment .
LoSeMA_ODP:isDescribedBy rdf:type owl:ObjectProperty ;
       rdfs:domain DBCargo:DangerousAndMilitary ;
       rdfs:range LoSeMa_ODP:HazMat .
DBCargo:Survaillance rdf:type owl:Class ;
       rdfs:subClassOf LoSeMa_ODP:Guarded ;
       rdfs:subClassOf LoSeMa_ODP:TrackAndTrace .
```

The flexibility is inherent in the approach of ODPs. The reusability has been shown with the help of the two use cases.

Querying is proofed with the help of the competency questions CQ_1 and CQ_5 of section 2.1. They allow to find a list of services and their operators from the service map and thus enable automated retrieval of services from specific categories that are able to meet the requirements of the customer:

CQ$_1$: Which services enable the transportation of dangerous goods on rail in southern Europe?

```
@prefix LoSeMa_ODP:
<https://github.com/Michael-Gloeckner/LoSeMa_ODP#>
@prefix LoSe_ODP:
<https://github.com/Michael-Gloeckner/LoSe_ODP#>
SELECT LogisticsService
FROM <https://github.com/Michael-Gloeckner/LoSeMa_ODP#>
WHERE {
LoSeMA_ODP:Physical rdfs:subClassOf
       LoSeMa_ODP:Transportation.
LoSeMA_ODP:Condition LoSeMa_ODP:isDescribedBy
       LoSeMa_ODP:HazMat.
LoSeMa_ODP:Transportation LoSeMa_ODP:hasModeOfTransport
       LoSeMa_ODP:ModeOfTransport.
LoSeMa_ODP:ModeOfTransport rdfs:subClassOf
       LoSeMa_ODP:Rail.
LoSeMa_ODP:Region LoSeMa_ODP:isDescribedBy
       LoSeMa_ODP:GeoArea.
GeoArea:SouthernEurope rdfs:subClassOf
       LoSeMa_ODP:GeoArea.
}
```

CQ$_5$: Where are inter-modal hubs in Germany for open sea to rail transshipment?

```
@prefix LoSeMa_ODP:
<https://github.com/Michael-Gloeckner/LoSeMa_ODP#>
@prefix LoSe_ODP:
<https://github.com/Michael-Gloeckner/LoSe_ODP#>
SELECT Region
FROM <GeoArea#>
WHERE {
GeoArea:Germany rdfs:subClassOf
       LoSeMa_ODP:GeoArea.
LoSeMa_ODP:Handling LoSeMa_ODP:hasModeOfTransport
       LoSeMa_ODP:Rail.
LoSeMa_ODP:Handling LoSeMa_ODP:hasModeOfTransport
       LoSeMa_ODP:Sea.
}
```

Main feature of the conceptual framework 'logistics service map' is the domain-driven structuring of logistics services in order to retrieve those services that best match the specific capability and functionality requested by a customer. The presented queries outline the enabling of this feature. Summarizing, the LoSeMa_ODP is positively evaluated to enable domain-specific structuring of services and to be flexible and reusable.

3 CONCLUSION AND FUTURE WORK

The implementation of the cloud logistics paradigm is based on the pooling of resources and services from heterogeneous LSP in order to combine the resources from those different LSP. The resources are encapsulated into modular services in order to enable the creation of customer-specific complex logistics services. Especially, larger networks face the challenge of the different wordings, namings and descriptions of different LSP, which is based on their heterogeneity and that results in a semantic gap. The solution to this in the cloud logistics paradigm is found in an ontological approach in general and in ontology design pattern in particular. This semantic gap also effects the structuring of the logistics services. Accordingly, an ODP to support and guide the creation of ontologies focusing on the structuring of logistics services is required.

In this paper, an ODP for the structuring of logistics services was developed following the NeOn methodology. The created LoSeMa_ODP (Logistics Service Map Ontology Design Pattern) is based on a large set of incorporated and analyzed ontological and non-ontological approaches. The essential structuring concepts of the logistics domain are distilled into one ODP. Hence, the structuring can be easily mapped and an ontological connection (with owl:sameAs) between similar concepts of different LSP can be set up and the semantic gap s closed. The created ODP is semantically richer than taxonomies or thesauri. The evaluation is done according to the FEDS framework and is based on two examples from applied structuring of big and influental logistics service providers. The ODP is positively evaluated to meet the functional requirements of structuring and retrieval and further to fulfill the properties of flexibility and re-usability.

The paper presents the first scientific approach towards an ontology design pattern for logistics service structuring. The creation of ODP for logistics holds enormous potential to support digitalization and collaboration between various actors of the logistics service industry in general and for the emerging cloud logistics paradigm in particular. Implications for researchers is one of the first approaches towards linked data in logistics. Further research steps have to focus on further ODPs, such as *GeoArea*, *HazMat*, or an ODP about roles and stakeholders in the context of logistics, in order to extend the foundation for the ontological development of cloud logistics.

ACKNOWLEDGMENTS

The work presented in this paper was funded by the German Federal Ministry of Education and Research within the project Logistik Service Engineering und Management (LSEM). More information can be found under the reference BMBF 03IPT504X and on the website http://lsem.de/.

REFERENCES

[1] 2012. *ADR - European Agreement Concerning the International Carriage of Dangerous Goods by Road: Applicable as from 1 January 2013.* United Nations, New York [etc.].

[2] Nilesh Anand, Mengchang Yang, J.H.R. van Duin, and Lori Tavasszy. 2012. GenCLOn: An ontology for city logistics. *Expert Systems with Applications* 39, 15 (2012), 11944–11960. https://doi.org/10.1016/j.eswa.2012.03.068

[3] Franz Baader. 2004. *The description logic handbook: Theory, implemention, and applications* (2. repr ed.). Cambridge Univ. Press, Cambridge [u.a.].

[4] Charu Chandra and Armen Tumanyan. 2007. Organization and problem ontology for supply chain information support system. *Data & Knowledge Engineering* 61, 2 (2007), 263–280. https://doi.org/10.1016/j.datak.2006.06.005

[5] Yu-Liang Chi. 2010. Rule-based ontological knowledge base for monitoring partners across supply networks. *Expert Systems with Applications* 37, 2 (2010), 1400–1407. https://doi.org/10.1016/j.eswa.2009.06.097

[6] Laura Daniele and Luis Ferreira Pires. 2013. An ontological approach to logistics. In *Enterprise Interoperability, Research and Applications in the Service-oriented Ecosystem, IWEI 2013*, M. Zelm, M.J. van Sinderen, and G. Doumeingts (Eds.). ISTE Ltd, John Wiley & Sons, Inc, Surrey, UK, 199–213. http://doc.utwente.nl/88351/

[7] Werner Delfmann and Falco Jaekel. The Cloud - Logistics for the Future? Discussionpaper. (????). http://www.bvl.de/misc/filePush.php?id=18910&name=Discussionpaper+Cloud+Logistis

[8] Tobias Engel, Manoj Bhat, Venkatesh Vasudhara, Suparna Goswami, and Helmut Krcmar. 2014. An Ontology-based Platform to Collaboratively Manage Supply Chains. In *25th Annual Conference of the Production and Operations Management Society (POMS)*. 1–10. https://www.pomsmeetings.org/ConfProceedings/051/FullPapers/Final%20Full%20length%20Papers/051-0705.pdf

[9] Masoud Esmaeilikia, Behnam Fahimnia, Joeseph Sarkis, Kannan Govindan, Arun Kumar, and John Mo. 2014. Tactical supply chain planning models with inherent flexibility: definition and review. *Annals of Operations Research* (2014).

[10] M. Fayez, L. Rabelo, and M. Mollaghasemi. 2005. Ontologies for Supply Chain Simulation Modeling. In *Winter Simulation Conference, 2005.* 2364–2370. https://doi.org/10.1109/WSC.2005.1574527

[11] Marco Franke, Till Becker, Martin Gogolla, Karl A. Hribernik, and Klaus-Dieter Thoben. 2016. Interoperability of Logistics Artifacts: An Approach for Information Exchange Through Transformation Mechanisms. In *Dynamics in Logistics*, Michael Freitag, Herbert Kotzab, and Jürgen Pannek (Eds.). Springer International Publishing, Cham, 469–479. https://doi.org/10.1007/978-3-319-45117-6{_}41

[12] Aldo Gangemi. 2005. Ontology Design Patterns for Semantic Web Content. In *The semantic Web - ISWC 2005*, Yolanda Gil, Enrico Motta, V. Richard Benjamins, and Mark A. Musen (Eds.). Lecture Notes in Computer Science, Vol. 3729. Springer, Berlin, 262–276. https://doi.org/10.1007/11574620{_}21

[13] Guido L. Geerts and Daniel E. O'Leary. 2014. A supply chain of things: The EAGLET ontology for highly visible supply chains. *Decision Support Systems* 63 (2014), 3–22. https://doi.org/10.1016/j.dss.2013.09.007

[14] Michael Glöckner, Christoph Augenstein, and André Ludwig. 2014. Metamodel of a Logistics Service Map. In *Business Information Systems*, Wil van der Aalst, John Mylopoulos, Michael Rosemann, Michael J. Shaw, Clemens Szyperski, Witold Abramowicz, and Angelika Kokkinaki (Eds.). Lecture Notes in Business Information Processing, Vol. 176. Springer International Publishing, Cham, 185–196. https://doi.org/10.1007/978-3-319-06695-0{_}16

[15] Michael Glöckner and André Ludwig. 2016. LoSe ODP - An Ontology Design Pattern for Logistics Services. In *Workshop on Ontology and Semantic Web Patterns (7th edition)*, Pascal Hitzler, Karl Hammer, Monika Solanki, Agnieszka Lawrynowicz, Andrea Nuzzolese, and Adila Krisnadhi (Eds.). http://ontologydesignpatterns.org/wiki/images/f/fb/WOP2016_paper_14.pdf

[16] Michael Glöckner, André Ludwig, and Bogdan Franczyk. 2017. Go with the Flow - Design of Cloud Logistics Service Blueprints. In *Proceedings of the 50th Hawaii International Conference on System Sciences (HICSS) 2017.*

[17] Silvio Gonnet, Marcela Vegetti, Horacio Leone, and Gabriela Henning. 2007. SCOntology. In *Adaptive technologies and business integration*, Maria Manuela Cruz-Cunha, Bruno Conceicao Cortes, and Goran Putnik (Eds.). Idea Group Reference, Hershey PA, 137–158. https://doi.org/10.4018/978-1-59904-048-6.ch007

[18] Timm Gudehus and Herbert Kotzab. 2012. *Comprehensive Logistics.* Springer Berlin Heidelberg, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-24367-7

[19] Bernhard Holtkamp, Sebasti Steinbuss, Heiko Gsell, Thorsten Loeffeler, and Ulrich Springer. 2010. Towards a Logistics Cloud. In *2010 Sixth International Conference on Semantics Knowledge and Grid (SKG)*. 305–308. https://doi.org/10.1109/SKG.2010.46

[20] Julia Hoxha, Andreas Scheuermann, and Stephan Bloehdorn. 2010. An approach to formal and semantic representation of logistics services. In *Proceedings of the Workshop on Artificial Intelligence and Logistics (AILog), 19th European Conference on Artificial Intelligence (ECAI 2010), Lisbon, Portugal.* 73–78.

[21] Christoph Klotzer and Alexander Pflaum. 2015. Cyber-physical systems as the technical foundation for problem solutions in manufacturing, logistics and supply chain management. In *2015 5th International Conference on the Internet of Things (IOT)*. 12–19. https://doi.org/10.1109/IOT.2015.7356543

[22] John Langley and Mindy Long. 2017. 2017 Third-Party Logistics Study: The State of Logistics Outsourcing: Results and Findings of the 21st Annual Study. 21 (2017).

[23] Joerg Leukel and Stefan Kirn. 2008. A Supply Chain Management Approach to Logistics Ontologies in Information Systems. In *Business Information Systems*, Witold Abramowicz and Dieter Fensel (Eds.). Lecture Notes in Business Information Processing, Vol. 7. Springer, Berlin and Heidelberg, 95–105. https://doi.org/10.1007/978-3-540-79396-0{_}9

[24] Jörg Leukel, Stefan Kirn, and Thomas Schlegel. 2011. Supply Chain as a Service: A Cloud Perspective on Supply Chain Systems. *IEEE Systems Journal* 5, 1 (2011), 16–27. https://doi.org/10.1109/JSYST.2010.2100197

[25] Dongmin Li, Xiao Xue, Shuhui Ding, and Cuiyun Li. 2014. OWL 2 Based Validation and Modeling of Logistics Domain Ontology. *International Journal of Artificial Intelligence and Application for Smart Devices* 2, 2 (2014), 1–8. www.sersc.org/journals/IJAIASD/vol2_no2/1.pdf

[26] Wenfeng Li, Ye Zhong, Xun Wang, and Yulian Cao. 2013. Resource virtualization and service selection in cloud logistics. *Journal of Network and Computer Applications* 36, 6 (2013), 1696–1704. https://doi.org/10.1016/j.jnca.2013.02.019

[27] Yan Lu, Hervé Panetto, Yihua Ni, and Xinjian Gu. 2013. Ontology alignment for networked enterprise information system interoperability in supply chain environment. *International Journal of Computer Integrated Manufacturing* 26, 1-2 (2013), 140–151. https://doi.org/10.1080/0951192X.2012.681917

[28] Azad M. Madni, Weiwen Lin, and Carla C. Madni. 2001. IDEONTM: An extensible ontology for designing, integrating, and managing collaborative distributed

enterprises. *Systems Engineering* 4, 1 (2001), 35–48. https://doi.org/10.1002/1520-6858(2001)4:1{\T1\textless}35::AID-SYS4{\T1\textgreater}3.0.CO;2-F

[29] Lars Mathiassen, A. Munk-Madsen, Peter Axel Nielsen, and Jan Stage. 2000. *Object-Oriented Analysis and Design.* Marko, Aalborg.

[30] Deborah McGuinnes and Frank van Harmelen. 2012. OWL 2 Web Ontology Language Document Overview (Second Edition): W3C Recommendation 11 December 2012. (2012). https://www.w3.org/TR/owl2-overview/

[31] Andreas Metzger, Rod Franklin, and Yagil Engel. 2012. Predictive Monitoring of Heterogeneous Service-Oriented Business Networks: The Transport and Logistics Case. In *Annual SRII global conference (SRII), 2012.* IEEE, Piscataway, NJ, 313–322. https://doi.org/10.1109/SRII.2012.42

[32] Pierre-Alain Millet, Lorraine Trilling, Thierry Moyaux, and Omar Sakka. 2013. Ontology of SCOR for the Strategic Alignment of Organizations and Information Systems. In *Supply Chain Performance*, Val?rie Botta-Genoulaz, Jean-Pierre Campagne, Daniel Llerena, and Claude Pellegrin (Eds.). Wiley, London, 171–210.

[33] Elisa Negri, Sara Perotti, Luca Fumagalli, Gino Marchet, and Marco Garetti. 2017. Modelling internal logistics systems through ontologies. *Computers in Industry* 88 (2017), 19–34. https://doi.org/10.1016/j.compind.2017.03.004

[34] Ken Peffers, Marcus Rothenberger, Tuure Tuunanen, and Reza Vaezi. 2012. Design Science Research Evaluation. In *Design science research in information systems*, Ken Peffers (Ed.). Lecture Notes in Computer Science, Vol. 7286. Springer, Heidelberg, 398–410. https://doi.org/10.1007/978-3-642-29863-9{_}29

[35] Valentina Presutti and Aldo Gangemi. 2008. Content Ontology Design Patterns as Practical Building Blocks for Web Ontologies. In *Conceptual modeling - ER 2008*, Qing Li (Ed.). LNCS sublibrary. Information systems and application, incl. Internet/Web, and HCI, Vol. 5231. Springer, Berlin, 128–141. https://doi.org/10.1007/978-3-540-87877-3{_}11

[36] Simon Rodan and Charles Galunic. 2004. More than network structure: How knowledge heterogeneity influences managerial performance and innovativeness. *Strategic Management Journal* 25, 6 (2004), 541–562. https://doi.org/10.1002/smj.398

[37] Omar Sakka, Pierre-Alain Millet, and Valérie Botta-Genoulaz. 2011. An ontological approach for strategic alignment: A supply chain operations reference case study. *International Journal of Computer Integrated Manufacturing* 24, 11 (2011), 1022–1037. https://doi.org/10.1080/0951192X.2011.575798

[38] Andreas Scheuermann and Julia Hoxha. 2012. Ontologies for Intelligent Provision of Logistics Services. In *ICIW 2012 : The Seventh International Conference on Internet and Web Applications and Services.* 106–111.

[39] Andreas Scheuermann and Joerg Leukel. 2014. Supply chain management ontology from an ontology engineering perspective. *Computers in Industry* 65, 6 (2014), 913–923. https://doi.org/10.1016/j.compind.2014.02.009

[40] Rohit Kr. Singh and P. Acharya. 2013. Supply Chain Flexibility: A Frame Work of Research Dimensions. *Global Journal of Flexible Systems Management* 14, 3 (2013), 157–166. https://doi.org/10.1007/s40171-013-0039-4

[41] Tomi Solakivi, Juuso Töyli, and Lauri Ojala. 2013. Logistics outsourcing, its motives and the level of logistics costs in manufacturing and trading companies operating in Finland. *Production Planning & Control* 24, 4-5 (2013), 388–398. https://doi.org/10.1080/09537287.2011.648490

[42] Mari Carmen Suárez-Figueroa, Asunción Gómez-Pérez, and Mariano Fernández-López. 2012. The NeOn Methodology for Ontology Engineering. In *Ontology Engineering in a Networked World*, Mari Carmen Suárez-Figueroa, Asunción Gómez-Pérez, Enrico Motta, and Aldo Gangemi (Eds.). Springer Berlin Heidelberg, Berlin, Heidelberg, 9–34. https://doi.org/10.1007/978-3-642-24794-1{_}2

[43] John Venable, Jan Pries-Heje, and Richard Baskerville. 2014. FEDS: A Framework for Evaluation in Design Science Research. *European Journal of Information Systems* (2014). https://doi.org/10.1057/ejis.2014.36

[44] Xiaohuan Wang, T. N. Wong, and Zhi-Ping Fan. 2013. Ontology-based supply chain decision support for steel manufacturers in China. *Expert Systems with Applications* 40, 18 (2013), 7519–7533. https://doi.org/10.1016/j.eswa.2013.07.061

5.2 Executive Summary

The paper contains the technical basis of the *map* that facilitates the management of cloud logistics service. With the help of the NeOn methodology and a literature review, the field of ODP and other ontological sources in the context of logistics is analyzed, existing approaches are conceptualized, merged, and the essentials of logistics service structuring are extracted. With those essentials, the *Logistics Service Map Ontology Design Pattern (LoSeMa ODP)* is developed. Competency questions and some first usage examples complement the paper. The analytical and design method is NeOn methodology following Suárez-Figueroa et al. [2012]. The paper answers RQ_4 (see Section 1.2) by dividing it into two sub-questions:

- What are existing logistics ontologies and what are essential structuring concepts of logistics services that could be re-used?
- What is a suitable ontology design pattern for the structuring of logistics services?

The semantic web community has not paid much attention on the logistics domain yet. The LoSe ODP [Glöckner and Ludwig, 2017a] is the only existing ODP in literature dealing with logistics issues. There are some other approaches of logistics ontologies in literature. Only the LoSe ODP can be considered linked data in terms of the W3C-standard 1. The gap of an ODP concerning the structuring of logistics services is closed by the current paper, see Figure 5.1.

Main aspects of structuring in logistics service maps are domain-specific dimensions, such as regions of service provision, speed of provision, and the phase of the process (production, outbound, transportation, and inbound). The characteristic of service, which could be either informational or physical, is another essential structuring criterion. Furthermore, special conditions that demand special skills and legal authorization (e.g. cooling chain, or hazardous materials) are an important criterion for structuring of logistics services. The essential structuring concepts of the logistics domain are distilled into one ODP. Hence, the structuring can easily be mapped and an ontological connection (with `owl:sameAs`) between similar concepts of different LSP or the establishment of subclasses can be set up and the semantic gap is closed. By reasoning and interference, implicit knowledge can be derived. This semantic approach enables a LI to bridge existing syntactical gaps and make logistics resource structurings from heterogeneous LSP compatible with each other. The evaluation is done according to the FEDS framework [Venable et al., 2014] and is based on two examples from applied structuring of big and influental LSPs. The ODP is positively evaluated to meet the functional requirements of structuring and retrieval and further to fulfill the properties of flexibility and re-usability.

In terms of contribution type level (see Table 1.2) and the kind of knowledge contribution (see Table 1.9), the artifact of the paper can be characterized as follows: The

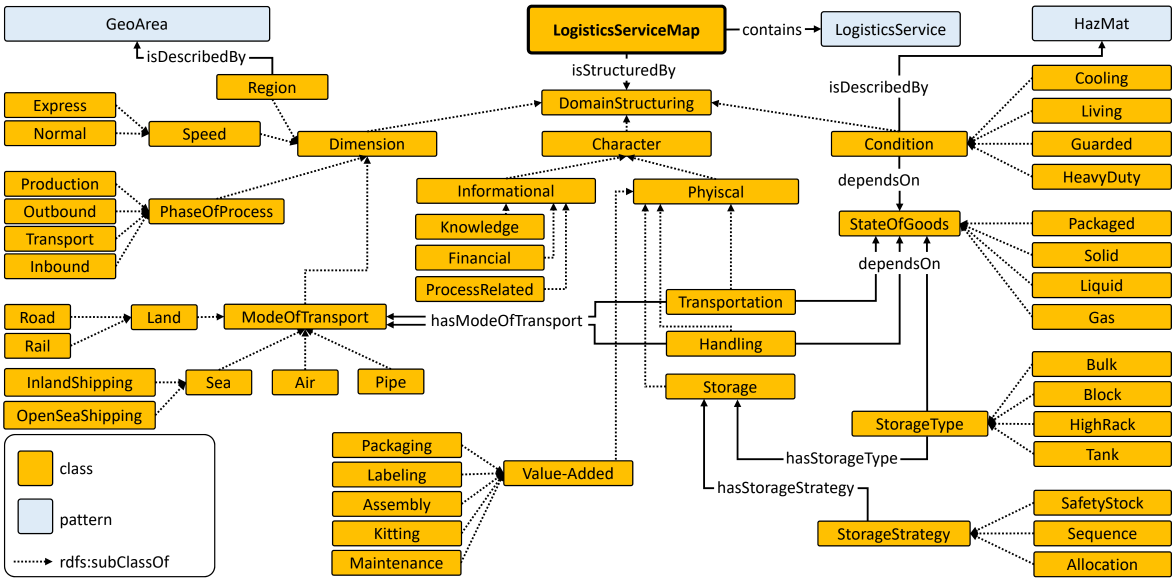

Figure 5.1: Schematic view of the ontology design pattern for logistics service maps.

concept of an ODP is a known solution that is adopted to a new problem field. Thus, it can be considered an exaptation. The LoSeMa ODP can be applied to a range of problems and specialized according to special conditions of several logistics networks and constraints, thus it can be located on the second level of contribution type.

This papers complements the conceptual foundation for the management of cloud logistics service structuring ("service map") (#3) and lays the technical foundation for a semantic approach of cloud logistics service structuring. The results are further used for the prototype (#6), as well as transitively in the consolidation and research roadmap (#8).

6 Service Granularity Framework

Glöckner, Michael; Ludwig, André; Franczyk Bogdan (2016): How Low Should You Go? - Conceptualization of the Service Granularity Framework. In: Proceedings of the European Conference on Information Systems (ECIS) 2016, Istanbul, Turkey, June 12-15, 2016. Research Papers. 32. [Glöckner et al., 2016b]

6.1 "How Low Should You Go? - Conceptualization of the Service Granularity Framework"

Table 6.1: Meta data of the publication (Service Granularity Framework).

DOI	-
URL	http://aisel.aisnet.org/ecis2016_rp/32
Type	Conference Paper, Proceedings
Publication in	ECIS (European Conference on Information Systems) 2016 Proceedings
Editor	-
Series Title	ECIS Proceedings
ISSN / ISBN	-
Publisher	-
Place of Publication	Istanbul, Turkey (ECIS 2016)
Ranking	CORE: A-ranked (conference) VHB: B-ranked (proceedings) h-index: -

Summer 6-15-2016

HOW LOW SHOULD YOU GO? - CONCEPTUALIZATION OF THE SERVICE GRANULARITY FRAMEWORK

Michael Glöckner
Leipzig University, gloeckner@wifa.uni-leipzig.de

André Ludwig
Logistics University, andre.ludwig@the-klu.org

Bogdan Franczyk
Leipzig University, franczyk@wifa.uni-leipzig.de

HOW LOW SHOULD YOU GO? - CONCEPTUALIZATION OF THE SERVICE GRANULARITY FRAMEWORK

Complete Research

Glöckner, Michael, Leipzig University, Leipzig, Germany, gloeckner@wifa.uni-leipzig.de

Ludwig, André, Kühne Logistics University, Hamburg, Germany, andre.ludwig@the-klu.org

Franczyk, Bogdan, Wrocław University of Economics, Wrocław, Poland; Leipzig University, Leipzig, Germany, franczyk@wifa.uni-leipzig.de

Abstract

With an ongoing division of labor and concentration on core competencies in logistics, the flexibility and quality in logistics services can be increased in terms of contracting specialists for each step in a supply chain. In order to participate in such an environment and act successfully on the market, it is essential for logistics service providers to follow a service oriented paradigm and modularize their service portfolio from static end-to-end solutions to a flexible set of modular services. One of the main challenges is to find a 'suitable' level of granularity for the modularization of existing logistics services. In this paper a conceptual framework of service granularity levels is developed. A systematic literature review is conducted in order to find existing concepts of service granularity. Findings are analyzed and finally synthesized towards their suitability for logistics services. Domain specific composition is supported by the logistics service map concept that contains catalog and construction kit for modular services. The paper's contribution is a Service Granularity Framework dedicated to specialized scholars of service science and practitioners of logistics.

Keywords: Service, Granularity, Framework, Logistics, Literature Review.

1 Introduction

The service based industry logistics (Gudehus and Kotzab, 2012) is facing the trends outsourcing, division of labor, and concentration on core competencies (Langley and Long, 2015). The expected benefits are a higher flexibility (Solakivi, Töyli, and Ojala, 2013) due to interchangeable stakeholders, and a higher quality from specialists for every task of a supply chain (Wilding and Juriado, 2004). The adoption of a service-oriented paradigm (as desribed by Erl (2008)) can lead to an increased performance (Kumar, Dakshinamoorthy, and Krishnan, 2007) of logistics service providers (LSP), in order to remain competitive and to participate successfully on such a flexible and service oriented market. Accordingly, services must be of modular character as this paradigm is based on encapsulation, composability, loose coupling, and reusability (Erl, 2008). Hence, modularization of their service portfolio from static end-to-end solutions to a flexible set of modular services is essential for LSP. Service modularity promises to achieve other benefits alongside increased flexibility in terms of cost and time reduction in planning and operation, and enhancing customer satisfaction by customized solutions while improving the efficiency of service systems (Blok et al., 2010; Meyer and DeTore, 2001; Voss and Hsuan, 2009).
Two major challenges arise in the context of service modularization. First, in order to have modular services for composition, it is necessary to decompose existing process portfolios and descriptions in advance. The extend of decomposition is a demanding issue. The challenge is to find the 'suitable' set of granularity levels for the modularization due to the trade-off between re-useability and (de-)composition effort (Steghuis, 2006). Hence, such a set is not depending on a particular number of levels. Rather the characteristics of the granularity levels - and the contained services - are of importance. Literature provides a number of papers and viewpoints concerning service granularity. In general service granularity can be defined as the scope of functionality exposed by a service (Papazoglou and van Heuvel, 2006), but a useful conceptualization of service granularity is missing as shown in the literature review of this paper. Second, evidence for the logistics domain is missing as well, thus, a further challenge is to extent the results and concepts of service granularity with both theoretical and empirical insights of the logistics domain. Finally, application and testing is provided by the logistics service map, an approach that combines a catalog and a construction system for modular logistics services. The paper's contribution is a *service granularity framework* for service oriented industries, such as logistics. Following the paper classification of Wieringa et al. (2006) the paper is a combination of 'proposal of solution' and 'evaluation research' as a novel framework for (de-)composition is proposed and applied to a problem domain. The paper's goal is to foster a granularity-driven delineation and description of services by answering the question: "What is the 'right' set of granularity levels for modular logistics services?" with the following particular research questions (and the used methods in parenthesis):

1. How can service granularity in existing literature be conceptualized? How can the concepts be consolidated within one single framework? (*method: systematic literature review*)
2. How can such a framework be applied to the logistics domain in order to improve handling service granularity of logistics networks? (*method: conceptual modeling based on logistics service map*)

After briefly introducing the reader to service modularity in section 2, the conducted systematic literature review is described and presented in section 3. Section 4 consolidates the concepts and presents the service granularity framework. In section 5 the framework is applied to the logistics domain. Section 6 concludes the paper and gives implications, threads to validity and an outlook on future research.

2 Background of Service Modularity

Service Granularity is an essential subtopic of service modularity. Hence, a brief introduction is given. Service modularity has been the focus of extensive research recently conducted by Dörbecker and Böhmann. They comprehensively describe concept, effects, measurements and design principles of service modularity. In two literature reviews they analyzed the concept and effects (Dörbecker and

Böhmann, 2013) as well as related measurement approaches (Dörbecker, Tokar, and Böhmann, 2015) of service modularity. Results show the origin of the modularity concept in other contexts (i.e. products, networks and software, (Baldwin and Clark, 2000; Schilling, 2000; Ulrich, 1994)) with several effects (e.g. cost reduction, customization, flexibility, re-design/re-usability or standardization (Blok et al., 2010; Meyer and DeTore, 2001; Voss and Hsuan, 2009)). Even though logistics is example domain of some papers (see Dörbecker and Böhmann (2013)), no domain-specific aspects are included in the results.
Further, they present a *Framework for Service Modularization* (Dörbecker, Böhm, and Böhmann, 2015), which they refine and extend by taking empirical experiences into account (Dörbecker and Böhmann, 2015). The first version of the framework consists of the phases of (1) element analysis, (2) module design and (3) architecture design. In order to focus on the inherent granularity problem and to make the approach more efficient, the pre-phase of 'framework calibration' is added in the extended version, i.e. first rough guidelines are set in order to reduce analysis and design efforts in the actual method. Essence is to work on a more abstract level forward and backward through the modularization phases and their input: (1) elements, (2) inter-dependencies, and (3) modules, with regards to goal-orientation of the architecture. The resulting points of orientation help to reduce efforts of modularization by only focusing on relevant elements, inter-dependencies and modules for a certain architecture. Those decicions in advance are influenced by the expected benefits and the resulting narrowed analysis objective. But still, a conceptualization of distinct granularity levels is missing.
With the extension of their approach, Dörbecker and Böhmann tackle the granularity problem in service modularization in terms of putting effort into preliminary considerations in order to reduce the effort during actual modularization phases. By defining decision points and guiding questions for crucial phases of modularization, they support the process but still leave a (too) high degree of freedom. A conceptualization of service granularity is missing and thus, focus of the following sections.

3 Systematic Literature Review

The method, which has been used to get a comprehensive overview of theoretical aspects and existing concepts of service granularity, follows the *systematic literature review* proposed by Vom Brocke et al. (2009). Figure 1 shows the methodological approach and its setup in the paper. After setting the research scope and describing the review incorporating the taxonomy of Cooper, the topic is conceptualized. Afterwards, the search itself, and the analysis and synthesis are presented. The used databases, keywords and exclusion criteria are described thoroughly in order to enable reproducibility and to ensure rigor, completeness and thoroughness of findings and to encourage other researchers to reuse the findings.

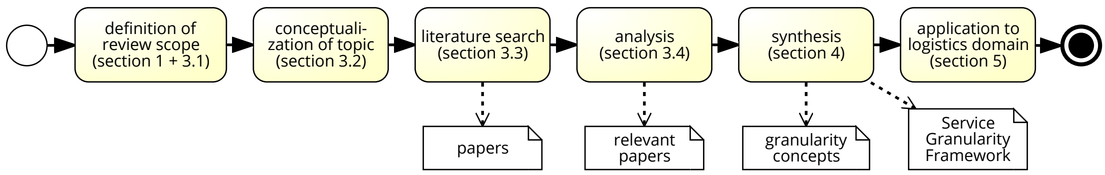

Figure 1. The systematic literature review approach following Vom Brocke et al. (2009).

3.1 Review Scope

The research scope of the review is to collect and analyze theoretical aspects and concepts of service granularity as already outlined by the first research question in the introduction. The conducted review can be described by the taxonomy of Cooper (1988) depicted in Figure 2. The literature review in this article (1) focuses on existing research outcomes in the field of service granularity. (2) goal is to integrate the resulting findings with requirements of the logistics domain. The (3) organization of the review is conceptual, as concepts and their comparison and interpretation are investigated. Neither a historical development over time nor the methodological aspects and foundations are investigated. (4) Neutral perspective is taken. Results of the study are presented to (5) audience of specialized scholars in the field of Information Systems in general and service oriented architectures in particular. Further, practitioners in the field of service management in general and logistics in particular are addressed. Due to a limitation on a handful of literature databases, (6) coverage can be described as representative.

<table>
<tr><th>Characteristic</th><th colspan="12">Categories</th></tr>
<tr><td>(1) focus</td><td colspan="3">research outcomes</td><td colspan="3">research methods</td><td colspan="3">theories</td><td colspan="3">applications</td></tr>
<tr><td>(2) goal</td><td colspan="4">integration</td><td colspan="4">criticism</td><td colspan="4">Central issues</td></tr>
<tr><td>(3) organization</td><td colspan="4">historical</td><td colspan="4">conceptual</td><td colspan="4">methodological</td></tr>
<tr><td>(4) perspective</td><td colspan="6">neutral perspective</td><td colspan="6">espousal of position</td></tr>
<tr><td>(5) audience</td><td colspan="3">specialized scholars</td><td colspan="3">general scholars</td><td colspan="3">Practitioners / politicians</td><td colspan="3">general public</td></tr>
<tr><td>(6) coverage</td><td colspan="3">exhaustive</td><td colspan="3">exhaustive and selective</td><td colspan="3">representative</td><td colspan="3">central / pivotal</td></tr>
</table>

Figure 2. Taxonomy of literature reviews (Cooper, 1988) and appropriate categories marked grey.

3.2 Conceptualization of Topic

The conceptualization of service granularity within the systematic literature review is an iterative process. The concept of service granularity evolves step by step from new insights unfolding by ongoing analysis of literature. Particularly of interest is the question of how to perceive granularity of services and by which distinct aspects service granularity can be defined and influenced. Objective is to derive a service granularity framework to give guidance to researchers and practitioners in granularity issues. This helps developing services in order to decide if further composition or decomposition is needed for services on particular levels with particular characteristics. Approaches, insights and concepts proposed by several authors are taken into account and synthesized for conceptualization. The generic definition of Papazoglou and van Heuvel (2006) is considered working definition and starting point: service granularity is the scope of functionality exposed by a service. The final concept of service granularity and the developed framework can be found in section 4 after the presentation of analysis.

3.3 Literature Search

The systematic literature review focuses on Service Granularity (SG). Databases are selected considering the criteria discussed by Dieste, Grimán, and Juristo (2009): content regularly updated, availability, quality of results. In order to ensure high quality, criteria are taking databases into account that are mostly journal-focused (e.g. science direct, web of science, springerlink, emerald) as they are likely to appear to be of higher quality than conference proceedings (Levy and Ellis, 2006). Only full research papers published within the time frame from 2000 to the present and in English language are considered. 130 papers are found (access date: 09.11.2015). The searched databases, the exact search terms and the related amount of papers found, analyzed, and categorized can be found in Table 1. During analysis, further citations appeared to be of interest where 9 more papers are selected from (forward and backward search). The total number of papers analyzed is 139. Papers are sorted exclusively to only one of the three categories. Criteria of category (1) - and thus exclusion criteria - are either papers that just mention SG as an 'important aspect' without giving a detailed description OR do not mention SG at all OR are duplicates. Consequently, 118 papers are sorted out completely. Category (2) comprises papers that reveal a more detailed description of SG and hence, help to build a deeper understanding of influencing aspects ("detailed description"). This category involves 10 papers. Finally, category (3) contains 11 paper with a strong influence on the perception of service granularity for the final results. They contribute information to the conceptualization and add value to answering the first research question ("granularity conception").

Table 1. Used databases, search terms, and amounts of papers sorted out or considered.

databases	not detailed not at all duplicates	detailed description	granularity conception	total	search term "service granularity"
science direct http://www.sciencedirect.com/	48	0	2	50	title OR all fields
web of science http://apps.webofknowledge.com/	10	2	0	12	title OR publication name OR topic
Springerlink http://link.springer.com/	53	6	2	61	exact phrase +* title *it is not clear whether fields are combined by logical AND or OR
Emerald http://www.emeraldinsight.com/	7	0	0	7	anywhere OR title OR keywords OR abstract
other	0	2	7	9	forward and backward search
total	118	10	11	139	

3.4 Analysis

The 21 not excluded papers are briefly introduced and described in the following 2 subsections. The 10 papers of category 2 are presented in 3.4.1 and the 11 papers of category 3 are introduced in 3.4.2.

3.4.1 Detailed Description (category 2)

The majority of articles examined discusses service granularity in a general abstract way. Commonly described is the essential trade-off between fine-grained services (increased network traffic, more difficult handling of errors, difficult service governance) and coarse-grained services (lower re-usability, more complex maintainability, higher likelihood of redundancy), see e.g. Kulkarni and Dwivedi (2008) and Steghuis (2006). Conclusion of those cases advice a balance between level of abstraction, likelihood of change, complexity of the service, and the desired level of cohesion and coupling.
Some other articles present measurements to compare granularity e.g. quantified as a combination of the number of components/services invoked, number of resources' state changes, (Bianchini et al. (2014), Feuerlicht (2011), Katzmarzik (2011), and Sindhgatta, Sengupta, and Ponnalagu (2009)). This makes granularity measurable, but still leaves room for interpretation and does not enable the decision for distinct characteristic levels. As well, automatic service identification (e.g. with the help of clustering, multi-objective particle swarm optimization) enables the change of granularity of services/tasks/ etc. but still those approaches do not provide guidance for the 'right' distinct granularity (e.g. CHATLA et al. (2011), Kim and Doh (2009), and Wang and Z. Li (2014)). Further, use cases are presented (e.g. Feuerlicht (2007)) bringing granularity into business case study context and solving one specific problem, but lack in generalization of the solution and deriving advice and guidance for a broader field of application (e.g. for a certain domain) on how to organize service granularity on distinct levels.

3.4.2 Granularity conception (category 3)

Erradi, Kulkarni, and Maheshwari (2007) introduce a 'service oriented decomposition process' with two iterative steps (1) service identification and (2) service granularity. During service identification a meet-in-the-middle approach is used to match services resulting from existing IT applications (bottom-up) with services decomposed from business processes (top-down) to business activities. The mapping is done on a (not explicitly named) level, where the granularity of IT-services is similar to the granularity of business activities. Their intersection contains 'fulfilled' services. 'Additional' services contain the IT functionality that is not yet matched to a specific business requirement and thus, has to be re-evaluated towards either retirement or extension of business service portfolio. Services from business processes that are not matched by any of the application functionality are named ’unmet’ services and reveal gaps of IT services that require new development. Concerning service granularity, services exposed to other systems should be adequately generic for a higher degree of reuse by several processes and/or users, while they should provide operations that correspond to business functions. Further emphasized is a *canonical schema* that is essential to enable a consistent representation of key business entities and to reduce syntactic and semantic mapping overheads between services. Moreover, Erradi et al. recommend *service metadata management* in order to support governance and identification of services based on business function.

Galster and Bucherer (2008) introduce the *Business-Goal-Service-Capability Graph* for alignment of business requirements and services. Business features are derived top-down from top-level business goals. These business features are to be matched 1:1 with service features that consist of service capabilities, which further consist of top level services. Summarizing, they introduce a 7-level hierarchy reaching from strategic goals down to basic services. The most interesting point is the combination of two different characteristics - i.e. *3 requirement-layers* (problem domain) and *3 service-layers* (solution domain) - via a *common level of abstraction* (level 4 in the middle), i.e. a connecting mapping level that enables a 1:1 connection between both domains (problem and solution). Hence, business requirements and services are aligned. The levels can be refined internally, but characteristics of the contained entities remain the same. There are criteria for the levels on both side next to the connection layer, i.e. business features shall be measurable and service features shall be comparable to those business features. Ma et al. (2009) propose an approach of 3 Levels for internal use as well that comprises (top-down) service, activity, and operation.

The *meet-in-the-middle* approaches are also emphasized by Huergo et al. (2014) to be more complete as they evaluate models from the highest level to the most detailed one. Furthermore, a distinction is made between granularity in service hierarchy and in service types. Combined with the measures of service width and depth introduced by Heinrich and Zimmermann (2012), *two orthogonal dimensions* of service granularity can be derived.

The stop criterion for the top-down decomposition should be chosen after Granell, Díaz, and Gould (2010), when a given process is specific and yet functional enough to not to be split again, since a *further division would not make sense*. Haesen et al. (2008) argue from a bottom-up and business value perspective that the composition of multiple fine-grained services causes more overhead in general for the consumer. Further, the properties of fine-grained services are characterized as significantly hindering cross-enterprise integration by Papazoglou and van Heuvel (2006). Also Haesen et al. (2008) mention that services with rich functionality are easier to be used and have higher reuse efficiency because of the larger contribution to business processes. Hence, companies try to bundle multiple services into *packages offered to consumers* with increased business value granularity. Hence, some services have a characteristic for internal use, while other (more coarse-grained) services are meant to be useful to customers and thus, bear a more external characteristic.

Cai et al. (2014) present a multi-granularity space in the context of multi-tenancy in SaaS. They state "it is necessary to build hierarchy relationships among services of different granularity to response to tenants’ multi-granularity requirements". Hence, the idea of a *hierarchy* of different granularity levels arises.

A further interesting finding is the approach of J. Liu et al. (2015). While granularity characteristics of other authors analyzed mainly focus on an either horizontal or vertical granularity, they divide granularity into *four categories*: atomic service, and service of either process, goal or role granularity. So this approach can be seen on a high abstract level able to cover a horizontal granularity (process) and a vertical/hierarchical granularity (role) and also the goal-oriented approach of Galster and Bucherer (2008).

The big amount of papers being sorted out during analysis possibly results from the difficulty of finding the ’right’ granularity and the discussed demanding trade offs. Thus, it seems authors don’t want to commit to specific details. But as the example of Dörbecker and Böhmann (2015) shows, a certain predefintion and determination in advance can help giving guidance, reduce effort, and thus foster service granularity.

3.4.3 Discussion

Summarizing the papers of category 2, the majority of the existing approaches perceives service granularity as the simple amount of functions being bundled by a service isolated from affected aspects and context. Contributions towards a substantial contemplation concerning different roles and perspectives, business contexts, and the resulting consequences are rare. Summarizing the papers of category 3, the existing body of literature towards service granularity concepts is extracted and presented. Consequently, the first part of the first research question is answered: There is no comprehensive concept of service granularity. Nevertheless, papers of category 3 reveal first concepts, that are to be taken into account for the development of a service granularity framework. None of the 21 papers set their focus on the logistics domain.

Key aspects analyzed are the concepts, definition and distinction of *vertical* and the *horizontal* granularity. Heinrich and Zimmermann (2012) propose a metric for measuring the granularity of IT services. In fact, they discuss a width metric and a depth metric and combinations of them for measuring service granularity. Taking this into account, it is appropriate to distinguish between a horizontal granularity for service on the same level (referring to and measured by the width) as well as a vertical granularity for services on different levels (referring to and measured by the depth). Huergo et al. (2014) describe this as granularity in service hierarchy (vertical) and service types (horizontal).

Haesen et al. (2008) describe different service types that are to be considered in a comprehensive framework, i.e. data granularity (input or output), functionality granularity (default or parametrized), and business value granularity.

Another influencing aspect is the overall *perspective*. Either choosing a top-down, a bottom-up or a hybrid meet-in-the-middle perspective (Erl, 2008; Huergo et al., 2014) of design and composition or decomposition is analyzed and finally related to the granularity. The perspective includes also a distinction of granularity for different stakeholders and their individual perception. Galster and Bucherer (2008) inspire with their idea of a common level of abstraction between two different stakeholders and a quantity of 3 levels for each stakeholder. The canonical schema as well as the service metadata management (following Erradi, Kulkarni, and Maheshwari (2007)) can be implemented on the common level of abstraction.

4 Synthesis - Conceptualization of Service Granularity

4.1 Horizontal vs. Vertical Granularity

When focusing on granularity, the term 'provider' and its perception is of high importance. It has to be emphasized that the term provider is in the current context explicitly not equal to organizational borders. It is more likely to be an abstraction and can also refer to one of several departments within a company, a group of firms, a network, or something in between.

Composition of services of one stakeholder or service provider (i.e. provider-internal) is defined as *horizontal granularity*. The number of bundled functions increases, thus the granularity is increasing. Within the horizontal granularity, a further distinction can be made by applying the definition of different service types, i.e. data granularity (input or output), functionality granularity (default or parametrized), and business value granularity.

The integration of services into composite services of other stakeholders (i.e. cross-organizational) is defined as *vertical granularity*. The granularity increases with the number of bundled functions. But, now characteristics and requirements change, as more stakeholders are involved. In contrast to the horizontal granularity, which aims at internal service composition, the vertical granularity focuses on hierarchical integration with other stakeholders. Thus, special emphasize is put on cross-organizational service composition, which results in characteristics of internal and external views on services.

4.2 The Service Granularity Framework

The concept of horizontal and vertical granularity is the main input of the conceptualization. The *Service Granulareity Framework* with three different provider levels (Top, Middle, Bottom) and a virtual common-mapping-level between different providers is introduced. Each level is defined by its dimensional focus (vertical or horizontal), its purpose and the characteristics of the contained elements.
The *provider levels* are defined as follows:

- **Top:** the top-level has a clear *dimensional focus* on vertical granularity. Its main *purpose* is the external representation of internal (composite) services, and the offering and connection of services to the next upward provider in the hierarchy. If no further upward provider exists, this level contains all composite services and functionality available in a service oriented environment or network. In this case, the next upward connection possibility is the end consumer of a service. The *characteristics* of the services contained in this level must comply with the common standards set in accordance with the upward provider by the next upward common-mapping-level (if existent) or in accordance with the demand of the end consumer.
- **Middle:** the middle-level has a clear *dimensional focus* on horizontal granularity. Its main *purpose* is the internal composition of atomic services (that may be invoked from external providers) in order to create composite services that meet the demand of external providers or end consumers. Granularity is not restricted on this level. Internal services can be composed or decomposed in a hierarchy of a multitude of (sub-)levels. The *characteristics* of the services contained in this level must comply with the provider-internal standards.
- **Bottom:** the bottom-level has a clear *dimensional focus* on vertical granularity. Its main *purpose* is the external representation of internal atomic services to a provider on next lower hierarchical level, and the demand and invocation of services from the next downward provider in the hierarchy. If no further downward provider exists, this level contains the most basic services and functionality of a service oriented environment. The *characteristics* of the services contained in this level must comply with the common standards set in accordance with the downward provider by the next downward common-mapping-level (if existent).

The *common-mapping-level* is defined as follows:

- **Common Mapping:** the common-mapping-level has a clear *dimensional focus* on vertical granularity. Its main *purpose* is the connection of two providers. It is situated between two providers, connecting the upward provider's bottom-level with the downward provider's top-level. It contains the commonly shared service standard (e.g. description, interfaces, etc.). The common-mapping-level is of virtual nature, as it does not contain services. Composition on this level is not allowed. It enables only 1:1 connections between two providers. It can be either created by the collaboration of two providers or (pre-)specified by a third party or service system. The *characteristics* of the elements (not services!) contained in this level set the common standards in accordance with the downward provider's top-level and the upward provider's bottom-level. The canonical schema as well as the service metadata management of a service network can be implemented on such a level.

With the given definitions, service systems and their inherent granularity can be conceptualized. Figure 3 illustrates the metamodel of the conceptual framework with its elements (levels and types of service granularity), and their relations. Multi-hierarchy is possible as after each three provider levels a new common-mapping-level - and thus, a further hierarchy level - can be established (see Figure 4). The total number of levels (n_l) can be calculated in dependancy of the number of provider-hierarchies x with the formular $n_l = x*3+(x-1)$ with $3*x$ provider levels per provider-hierarchy and $x-1$ common-mapping-levels between each 2 different provider-hierarchies. Hence, even complex service systems can be described and conceptual scalability is possible. There's no explicit starting point, hence a meet-in-the-middle approach is possible for (de-)composition. As the framework connects several existing concepts it is able to describe the existing approaches comprehensively and interrelate them (see discussion in 3.4.3).

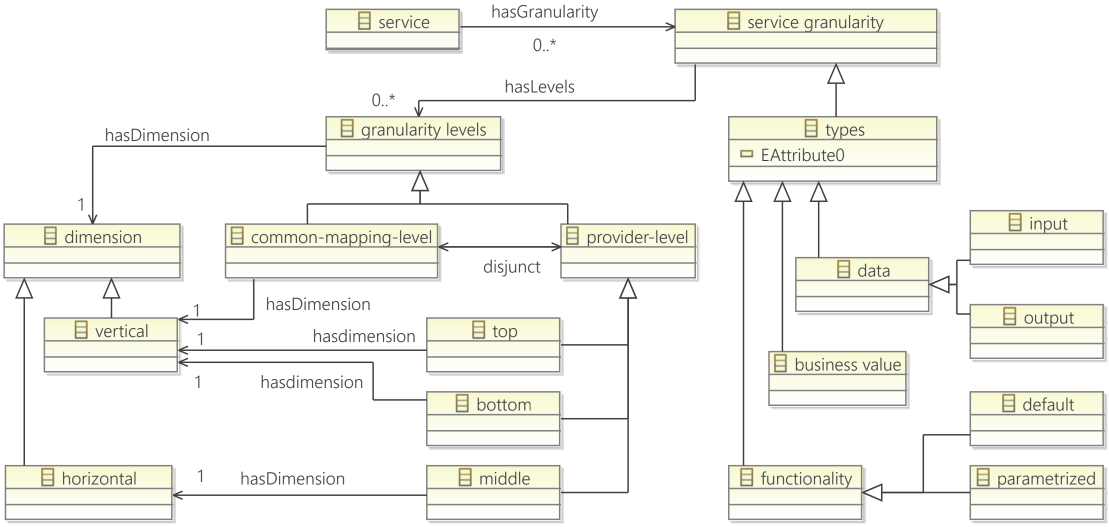

Figure 3. Conceptual framework of service granularity (types of granularity from Haesen et al. (2008)).

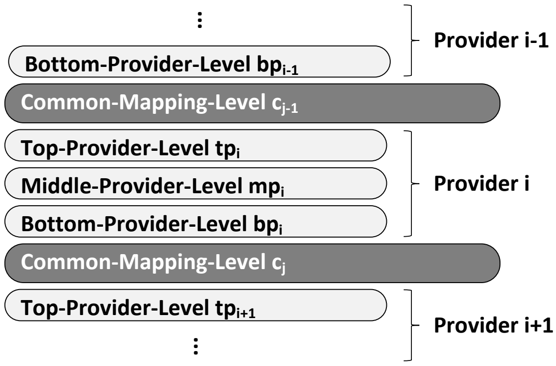

Figure 4. Resulting generic bundle of conceptual service granularity levels for each provider.

5 Application in Logistics

In the following section the developed Service Granularity Framework is applied to the logistics domain. This creates a proof of concept and gives advice for practitioners on how to tailor the service granularity framework to a logistics service network. After briefly introducing the requirements of the logistics domain, the logistics service map is presented as a concept for management and engineering of modular services in logistics. Finally, the framework is applied to a generic example of a logistics network consisting of a logistics integrator and several LSP.

5.1 Requirements of Modular Services in the Logistics Domain

Domain-related requirements are included to ensure suitability of the application to the logistics domain. With an ever increasing cost reduction in outsourced logistics (Langley and Long, 2015), LSP are facing an increased economic competition. Thus, their *privacy concerns* are on a high level (C. Liu, Q. Li, and Zhao, 2009) e.g. regarding their price politics. Further to pricing aspects, importance of information and know-how is emphasized. They are either proprietary and for *internal* use only or information and aspects are *externally* shown and provided to customers and/or collaboration partners in a cross-organizational business collaboration, e.g. see Norta et al. (2015). Furthermore, services are, firstly, characterized by the inclusion of external resources and know-how and an intensive contact to as well as integration of customers (Hipp and Grupp, 2005). Secondly, logistics networks are of dynamic character, as the loosely coupled LSP work together in a flexible way on demand (Solakivi, Töyli, and Ojala, 2013). Hence, the urgency of *collaboration* arises in order to maintain competitiveness and to participate successfully on such a customer oriented service market. *Common communication* is necessary within a network in order to increase efficiency of collaboration, visibility of available services in the network, and to increase value cocreation (Rai et al., 2012). At the very top-level, the whole *portfolio of services* available in the network has to be presented, as described in the approach of Kohlborn et al. (2009). Retrieval of atomic services and the related operating LSP (bottom-up) as well as recognition in case a specific function required by the customer is not available in the network (top-down): both capabilities are essential when creating composite services and demand for an *alignment* between top-level service portfolio and basic logistics function available in the network. Hence, a meet-in-the-middle approach is suitable. Summarizing, granularity issues in logistics have to consider different perspectives, internal and external aspects, as well as collaboration and privacy concerns.

5.2 Logistics Service Map

Offering a customizable approach for a logistics integrator, the logistics service map (Glöckner and Ludwig, 2013) satisfies the needs for supporting engineering and management of logistics services. This implies the creation of atomic services that can be composed to composite services. The conceptual aspects, like catalog function and the retrieval of services, are included with the structured categorization-pattern and the modular service construction functionality. Further, the service map postulates different granularity levels and viewpoints from basic service description up to a category overview. However, a more detailed description of the different granularity levels (number and characteristics) is missing. Fig. 5 shows a screenshot of the service map prototype. In the upper right, services can be chosen from the catalog and put into the editor in the lower right via drag-and-drop. Service-specific information and attributes can be displayed when changing the selected granularity to a more detailed level to foster planning and monitoring. Moreover, the unique standard of the available set of services within a network and the visualization foster a precise mediation and communication between all stakeholders during the whole service life-cycle. Service governance and meta-data management is unified by a given meta-model (Glöckner, Augenstein, and Ludwig, 2014).

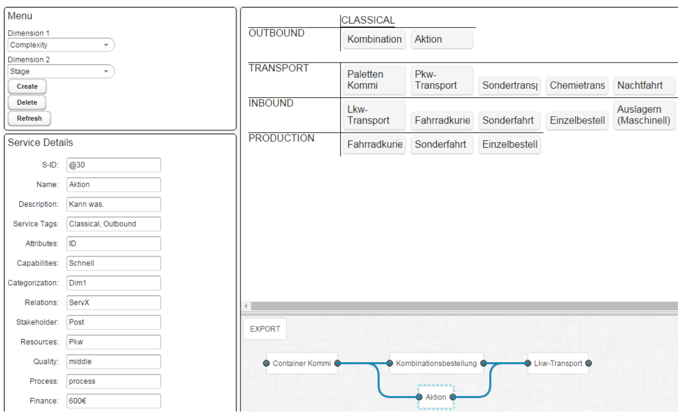

Figure 5. Visual snippet of the service map prototype.

With this approach, a logistics network is supported in retrieving services in different use cases. (a) Add a new LSP to the network and match its offered services to the existing set of services in a logistics network by adding the new LSP to the provider list of the particular service. (b) Develop a new composite service to meet a specific customer's need by selecting and composing services from the service catalog with the help of the editor. (c) Find compensational service or provider when realizing the urgency for re-planning or elimination of errors because of unpredictable disturbance in the network. (d) Detect the need to find further specialists when customer requirements can not be matched to existing services.
Summarizing, there are the perspective of the service providers on the one side and the perspective of the network, the logistics integrator and its customers on the other side. The service map concept seeks to align both perspectives in order to foster mediation through a common set of services that are available within a logistics network. Hence, a network character with internal and external views as well as a combined top-down and bottom-up perspective is emphasized.

5.3 Application of the Service Granularity Framework to the Logistics Domain

The developed framework is applied to the logistics domain by taking the requirements of logistics domain and the logistics service map concept from the former subsections into account. The example network consists of two LSP on one hierarchical level and the logistics integrator on the next higher hierarchical level. The service map concept seeks to align both hierarchical levels in order to foster mediation through a common set of available services within a logistics network. Hence, internal and external views as well as a meet-in-the-middle perspective, as well as mediation and alignment is outlined.
The service granularity framework is transferred to a logistics network comprising 2 exemplary hierarchical levels. Using the formular of section 4.2, the conceptual description contains $2*3$ provider levels and $2-1$ mapping levels, resulting in a framework with 7 levels of granularity (see Figure 6 and Table 2). The first three levels on top are dedicated to the hierarchy of the logistics integrator ('provider levels'), whereas the bottom three levels represent the hierarchy of the participating LSP ('provider levels' as well). The level in the middle (darker gray) acts as the 'common-mapping-level' containing the connecting entities between the two hierarchies of LSP and the logistics integrator. Table 2 gives typical examples of possible services for each particular granularity level. Assuming that logistics services are not further outsourced, the two LSP on the lower hierarchy form the basis of the network. Their basic level contains the most basic

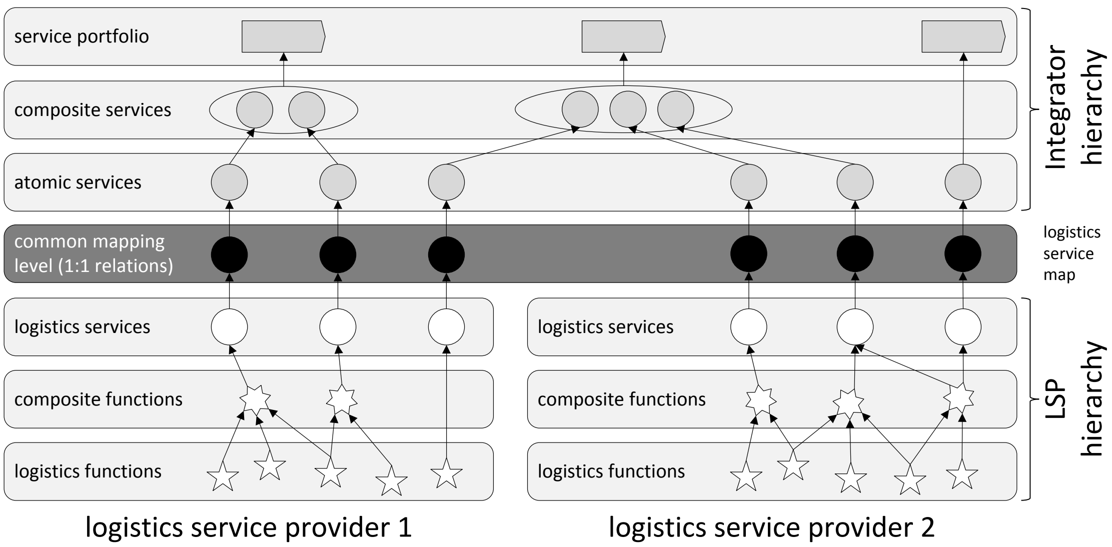

Figure 6. Service granularity framework applied to the example logistics service network.

Table 2. Seven service granularity levels of the example logistics service network.

Nr	Name	Description	Example
7	service portfolio	comprehensive logistics capabilities	automotive logistics in a particular region
6	composite services	service that fulfill complex customer demands	supply chain for particular product modules
5	atomic services	services that are available in a network	transportation, inbound, or warehousing
4	common mapping level	mapping entities	logistics service map
3	logistics services	services, LSPs offer to customers, services that are presented externally	inbound
2	composite functions	mix'n'match of logistics functions	unloading + quality check + labeling
1	logistics functions	finest in-dividable logistics functions, where part steps don't make sense	unloading + putting the entity to a particular destination

logistics functionality of the network that can not be split further (see also level 1 in Table 2). Functions can be composed by the LSP (level 2) until they reach a level of granularity of logistics services that are externally presented to customers, or the logistics network in our case (level 3). The logistics network sources the available logistics services of all LSP in the network as its atomic services (level 5). These are combined to composite services in order to fulfill complex customer demand (level 6). All atomic and composite services together shape the service portfolio of the logistics network that can be presented to the end consumer of the logistics service network (level 7). The important point of interaction between LSP and the logistics integrator (or network, respectively) is located on the common-mapping-level (level 4). With its mediating, aligning character and being viewable and accessible by the connected stakeholders, the logistics service map concept can be located on this level.

Summarizing, with the service granularity framework and especially with the given use case, a general guidance on how to handle service granularity in service provider networks, such as of the logistics domain, is given. A *Service Granularity Framework* is defined for conceptualization of and working with service granularity in general, and in the logistics domain in particular. Results may also be transferred to networks with more hierarchical levels. Other service oriented domains with similar requirements could benefit from the framework as well. With the description of the framework and the examples a given logistics service can be adequately characterized and asigned to a distinct granularity level. With the assignment the need for further (de-)composition for specific purposes can be revealed. Consequently, the second research question is answered.

6 Conclusion and Outlook

The paper's objective is to find the 'right' set of granularity levels in order to facilitate composition and decomposition of modular logistics services. In order to provide scientific evidence a systematic literature review on 'service granularity' was conducted. 139 papers about service granularity were found in total. Only 21 of them delivered detailed description or concepts. Even though different dimensions of granularity (horizontal, and vertical) are implicitly described in literature, there exists no explicit conceptualization of service granularity. An explicit definition of vertical and horizontal granularity has been synthesized. Subsequently, service granularity is conceptualized and the service granularity framework is developed. Special emphasize is put on cross-organizational service composition. Provider-levels and the common-mapping-level are defined by their dimensional focus, purpose and characteristics

of the contained services or entities. Finally, the developed framework is applied to a generic logistics use case in order to make results tangible for practitioners of the logistics industry as well.
The research questions presented in the introduction are answered by implementing suitable methods. The first research question is answered with a systematic literature review. A conceptual Service Granularity Framework is developed, mainly influenced by Erradi, Kulkarni, and Maheshwari (2007), Galster and Bucherer (2008), Heinrich and Zimmermann (2012), Huergo et al. (2014), and J. Liu et al. (2015). The second research question is answered with the help of conceptual modeling based on the logistics service map in order to tailor the results to the specific needs of the logistics domain. An applied generic use case illustrates the possibilities for service oriented industries and proves the applicability of the concept to logistics.
The systematic literature review reveals some threats to validity that are related to:

- Completeness: publications may have been left out because of the database selection considered. Further, technical limitations of the involved search engines are to be mentioned that can not be estimated nor influenced by the researchers. Moreover, mostly journal-focused databases are taken into account, as conference proceedings often tend to be seen as of lower quality (Levy and Ellis, 2006). 'Springerlink' with a rather mixed characteristic of journals and conference proceedings shows a higher hit ratio and also the considered papers in general are more likely to be from a conference proceeding. Hence, further research shall be expanded to more conference-focused databases.
- Reliability: in order to reduce bias, evaluation and interpretation of publications was conducted by all the authors. But even though a multi-revision strategy was adopted, analysis and synthesis are based one the opinions of the research team (human beings), and thus are not beyond bias.

Implication for research is, to the best of our knowledge, the first conceptual framework on service granularity. We hope to contribute a new perspective to the scientific discussion as well as a useful artifact to the research community. As the framework connects several existing concepts it is able to describe the existing approaches comprehensively and interrelate them.
We intend to encourage practitioners to understand the consequences of modular logistics services. Implications for practitioners result in a guidance on how to deal with service granularity in logistics networks. Further, guidance is given for assigning services with regards to their characteristics to a distinct granularity level. Hence, service engineering and management is facilitated and the need of further (de-)composition can be easily revealed. This could result in a higher flexibility of LSP and a higher service quality that leads to a higher customer satisfaction and increased competitiveness. Modularity is a widely discussed issue in literature, but applying the concept to business is still a demanding challenge in logistics.
Future research will focus on the mapping entities on the common-mapping-level. The definition of logistics specific service descriptions, inter-dependencies and interfaces is crucial in order to apply the developed framework. The application of the framework in use cases creates practical evidence and will lead to detailed feedback for further improvement. Extension of the literature review on more conference-based literature databases will improve the service granularity framework, as well.

Acknowledgment

The work presented in this paper was funded by the German Federal Ministry of Education and Research within the project *Logistik Service Engineering und Management* (LSEM). More information can be found under the reference BMBF 03IPT504X and on the website www.lsem.de.

References

Baldwin, C. Y. and K. B. Clark (2000). *Design rules*. Cambridge, Mass.: MIT Press. ISBN: 0262024667.

Bianchini, D., C. Cappiello, V. de Antonellis, and B. Pernici (2014). "Service Identification in Interorganizational Process Design." *IEEE Transactions on Services Computing* 7 (2), 265–278.

Blok, C. de, K. Luijkx, B. Meijboom, and J. Schols (2010). "Modular care and service packages for independently living elderly." *International Journal of Operations & Production Management* 30 (1), 75–97.

Cai, H., L. Cui, Y. Shi, L. Kong, and Z. Yan (2014). "Multi-tenant Service Composition Based on Granularity Computing." In: *2014 IEEE International Conference on Services Computing (SCC)*, pp. 669–676.

CHATLA, S., S. KADAM, D. KOLLURU, S. SINHA, A. VISWANDHUNI, and A. VAIDYA (2011). "Complex networks and SOA: Mathematical modelling of granularity based web service compositions." *Sadhana* 36 (4), 441–461.

Cooper, H. M. (1988). "Organizing knowledge syntheses: A taxonomy of literature reviews." *Knowledge in Society* 1 (1), 104–126.

Dieste, O., A. Grimán, and N. Juristo (2009). "Developing search strategies for detecting relevant experiments." *Empirical Software Engineering* 14 (5), 513–539.

Dörbecker, R., D. Böhm, and T. Böhmann (2015). "Measuring Modularity and Related Effects for Services, Products, Networks, and Software – A Comparative Literature Review and a Research Agenda for Service Modularity." In: *2015 48th Hawaii International Conference on System Sciences (HICSS)*, pp. 1360–1369.

Dörbecker, R. and T. Böhmann (2013). "The Concept and Effects of Service Modularity – A Literature Review." In: *46th Hawaii International Conference on System Sciences (HICSS)*, pp. 1357–1366.

— (2015). "Tackling the Granularity Problem in Service Modularization." In: *Twenty-first Americas Conference in Information Systems (AMCIS)*.

Dörbecker, R., O. Tokar, and T. Böhmann (2015). "Deriving Design Principles for Improving Service Modularization Methods - Lessons Learnt from the Complex Integrated Health Care Service System." In: *European Conference on Information Systems (ECIS) Completed Research Papers*.

Erl, T. (2008). *SOA: Principles of service design*. Upper Saddle River, NJ: Prentice Hall. ISBN: 978-0132344821.

Erradi, A., N. Kulkarni, and P. Maheshwari (2007). "Service Design Process for Reusable Services: Financial Services Case Study." In: *Service-Oriented Computing – ICSOC 2007*. Ed. by B. J. Krämer, K.-J. Lin, and P. Narasimhan. Vol. 4749. Lecture Notes in Computer Science. Springer Berlin Heidelberg, pp. 606–617. ISBN: 978-3-540-74973-8.

Feuerlicht, G. (2007). "Service Aggregation Using Relational Operations on Interface Parameters." In: *Service-Oriented Computing ICSOC 2006*. Ed. by D. Georgakopoulos, N. Ritter, B. Benatallah, C. Zirpins, G. Feuerlicht, M. Schoenherr, and H. R. Motahari-Nezhad. Vol. 4652. Lecture Notes in Computer Science. Springer Berlin Heidelberg, pp. 95–103. ISBN: 978-3-540-75491-6.

— (2011). "Simple Metric for Assessing Quality of Service Design." In: *Service-Oriented Computing*. Ed. by D. Hutchison, T. Kanade, J. Kittler, J. M. Kleinberg, F. Mattern, J. C. Mitchell, M. Naor, O. Nierstrasz, C. Pandu Rangan, B. Steffen, M. Sudan, D. Terzopoulos, D. Tygar, M. Y. Vardi, G. Weikum, E. M. Maximilien, G. Rossi, S.-T. Yuan, H. Ludwig, and M. Fantinato. Vol. 6568. Lecture Notes in Computer Science. Springer Berlin Heidelberg, pp. 133–143. ISBN: 978-3-642-19393-4.

Galster, M. and E. Bucherer (2008). "A Business-Goal-Service-Capability Graph for the Alignment of Requirements and Services." In: *2008 IEEE Congress on Services Part 1 (SERVICES-1)*, pp. 399–406.

Glöckner, M., C. Augenstein, and A. Ludwig (2014). "Metamodel of a Logistics Service Map." In: *Business Information Systems*. Ed. by W. van der Aalst, J. Mylopoulos, M. Rosemann, M. J. Shaw, C. Szyperski, W. Abramowicz, and A. Kokkinaki. Vol. 176. Lecture Notes in Business Information Processing. Springer International Publishing, pp. 185–196. ISBN: 978-3-319-06694-3.

Glöckner, M. and A. Ludwig (2013). "Towards a Logistics Service Map: Support for Logistics Service Engineering and Management." In: *Pioneering solutions in supply chain performance management: Proceedings of the Hamburg International Conference of Logistics (HICL) 2013*. Ed. by T. Blecker, W.

Kersten, and C. Ringle. Vol. 17. Supply chain, logistics and operations management. Eul, pp. 309–324. ISBN: 978-3844102673.

Granell, C., L. Díaz, and M. Gould (2010). "Service-oriented applications for environmental models: Reusable geospatial services." *Environmental Modelling & Software* 25 (2), 182–198.

Gudehus, T. and H. Kotzab (2012). *Comprehensive logistics*. Berlin Heidelberg: Springer-Verlag.

Haesen, R., M. Snoeck, W. Lemahieu, and S. Poelmans (2008). "On the Definition of Service Granularity and Its Architectural Impact." In: *Advanced Information Systems Engineering*. Ed. by Z. Bellahsène and M. Léonard. Vol. 5074. Lecture Notes in Computer Science. Springer Berlin Heidelberg, pp. 375–389. ISBN: 978-3-540-69533-2.

Heinrich, B. and S. Zimmermann (2012). "Granularity metrics for it services." In: *Proceedings of the International Conference on Information Systems (ICIS) 2012*, pp. 1–19.

Hipp, C. and H. Grupp (2005). "Innovation in the service sector: The demand for service-specific innovation measurement concepts and typologies." *Research Policy* 34 (4), 517–535.

Huergo, R. S., P. F. Pires, F. C. Delicato, B. Costa, E. Cavalcante, and T. Batista (2014). "A systematic survey of service identification methods." *Service Oriented Computing and Applications* 8 (3), 199–219.

Katzmarzik, A. (2011). "Product Differentiation for Software-as-a-Service Providers." *Business & Information Systems Engineering* 3 (1), 19–31.

Kim, Y. and K.-G. Doh (2009). "Formal Identification of Right-Grained Services for Service-Oriented Modeling." In: *Web Information Systems Engineering - WISE 2009*. Ed. by D. Hutchison, T. Kanade, J. Kittler, J. M. Kleinberg, F. Mattern, J. C. Mitchell, M. Naor, O. Nierstrasz, C. Pandu Rangan, B. Steffen, M. Sudan, D. Terzopoulos, D. Tygar, M. Y. Vardi, G. Weikum, G. Vossen, D. D. E. Long, and J. X. Yu. Vol. 5802. Lecture Notes in Computer Science. Springer Berlin Heidelberg, pp. 261–273. ISBN: 978-3-642-04408-3.

Kohlborn, T., E. Fielt, A. Korthaus, and M. and Rosemann (2009). "Towards a Service Portfolio Management Framework." In: *ACIS 2009 Proceedings*.

Kulkarni, N. and V. Dwivedi (2008). "The Role of Service Granularity in a Successful SOA Realization A Case Study." In: *2008 IEEE Congress on Services Part 1 (SERVICES-1)*, pp. 423–430.

Kumar, S., V. Dakshinamoorthy, and M. S. Krishnan (2007). "Does SOA Improve the Supply Chain? An Empirical Analysis of the Impact of SOA Adoption on Electronic Supply Chain Performance." In: *40th Annual Hawaii International Conference on System Sciences (HICSS'07)*, 171b.

Langley, J. and M. Long (2015). *2015 Third-Party Logistics Study: The State of Logistics Outsourcing: Results and Findings of the 19th Annual Study*. Ed. by C. John Langley. URL: `http://www.3plstudy.com/media/downloads/2015/2015-3PL-study-report.pdf`.

Levy, Y. and T. J. Ellis (2006). "A Systems Approach to Conduct an Effective Literature Review in Support of Information Systems Research." *Informing Science Journal* (Volume 9), 181–212.

Liu, C., Q. Li, and X. Zhao (2009). "Challenges and opportunities in collaborative business process management: Overview of recent advances and introduction to the special issue." *Information Systems Frontiers* 11 (3), 201–209.

Liu, J., K. He, J. Wang, F. Liu, and X. Li (2015). "Service organization and recommendation using multi-granularity approach." *Knowledge-Based Systems* 73, 181–198.

Ma, Q., N. Zhou, Y. Zhu, and H. Wang (2009). "Evaluating Service Identification with Design Metrics on Business Process Decomposition." In: *2009 IEEE International Conference on Services Computing*, pp. 160–167.

Meyer, M. and A. DeTore (2001). "PERSPECTIVE: Creating a platform-based approach for developing new services." *Journal of Product Innovation Management* 18 (3), 188–204.

Norta, A., L. Ma, Y. Duan, A. Rull, M. Kõlvart, and K. Taveter (2015). "eContractual choreography-language properties towards cross-organizational business collaboration." *Journal of Internet Services and Applications* 6 (1), 1.

Papazoglou, M. P. and W.-J. D. van Heuvel (2006). "Service-oriented design and development methodology." *International Journal of Web Engineering and Technology* 2 (4), 412.

Rai, A., P. A. Pavlou, G. Im, and S. Du (2012). "Interfirm IT Capability Profiles and Communications for Cocreating Relational Value: Evidence from the Logistics Industry." *MIS quarterly* 36 (1), 233–262.

Schilling, M. A. (2000). "Toward a general modular systems theory and its application to interfirm product modularity." *Academy of management review* 25 (2), 312–334.

Sindhgatta, R., B. Sengupta, and K. Ponnalagu (2009). "Measuring the Quality of Service Oriented Design." In: *Service-Oriented Computing*. Ed. by D. Hutchison, T. Kanade, J. Kittler, J. M. Kleinberg, F. Mattern, J. C. Mitchell, M. Naor, O. Nierstrasz, C. Pandu Rangan, B. Steffen, M. Sudan, D. Terzopoulos, D. Tygar, M. Y. Vardi, G. Weikum, L. Baresi, C.-H. Chi, and J. Suzuki. Vol. 5900. Lecture Notes in Computer Science. Springer Berlin Heidelberg, pp. 485–499. ISBN: 978-3-642-10382-7.

Solakivi, T., J. Töyli, and L. Ojala (2013). "Logistics outsourcing, its motives and the level of logistics costs in manufacturing and trading companies operating in Finland." *Production Planning & Control* 24 (4-5), 388–398.

Steghuis, C. (2006). *Service granularity in SOA-projects: A trade-off analysis*.

Ulrich, K. (1994). "Fundamentals of Product Modularity." In: *Management of Design*. Ed. by S. Dasu and C. Eastman. Springer Netherlands, pp. 219–231. ISBN: 978-94-010-4609-1.

Vom Brocke, J., A. Simons, B. Niehaves, K. Riemer, R. Plattfaut, and A. Cleven (2009). "Reconstructing the Giant: On the Importance of Rigour in Documenting the Literature Search Process." In: *Proceedings of the 17ˆth European Conference on Information Systems*. URL: `http://aisel.aisnet.org/ecis2009/161/`.

Voss, C. A. and J. Hsuan (2009). "Service Architecture and Modularity." *Decision Sciences* 40 (3), 541–569.

Wang, P. and Z. Li (2014). "Optimization Design Strategies and Methods of Service Granularity." In: *Proceedings of the Eighth International Conference on Management Science and Engineering Management*. Ed. by J. Xu, V. A. Cruz-Machado, B. Lev, and S. Nickel. Vol. 281. Advances in Intelligent Systems and Computing. Springer Berlin Heidelberg, pp. 1445–1455. ISBN: 978-3-642-55121-5.

Wieringa, R., N. Maiden, N. Mead, and C. Rolland (2006). "Requirements engineering paper classification and evaluation criteria: a proposal and a discussion." *Requirements Engineering* 11 (1), 102–107.

Wilding, R. and R. Juriado (2004). "Customer perceptions on logistics outsourcing in the European consumer goods industry." *International Journal of Physical Distribution & Logistics Management* 34 (8), 628–644.

6.2 Executive Summary

The paper contains the first comprehensive *conceptualization of service granularity*. Results of a systematic literature review on service granularity reveal certain implicit concepts and dimensions of service granularity in literature. Those concepts are synthesized towards a conceptual framework that guides the finding of the right amount and quality of granularity levels. The analytical method is a systematic literature review following Vom Brocke, Simons, Niehaves, et al. [2009]. The design approach is based on the method of conceptual modeling [Goos et al., 1999]. The evaluation is based on FEDS [Venable et al., 2014] and realized by a quick&simple strategy with an application example in the logistics industry. The paper answers RQ_5 (see Section 1.2) by dividing it into two sub-questions:

- How can service granularity in existing literature be conceptualized? How can the concepts be consolidated within one single framework?
- How can such a framework be applied to the logistics domain in order to improve handling service granularity of logistics networks?

Essential results comprise the conceptualization of service granularity and distinct granularity level concepts. First, a distinction is made between horizontal and vertical granularity. *Horizontal granularity* is the composition of services of one stakeholder or service provider (i.e. provider-internal). *Vertical granularity* is defined as the integration of services into composite services of other stakeholders (i.e. cross-organizational). Granularity level concepts are divided into provider levels on the one side and common-mapping-level on the other. *Provider levels* are used to manage the proprietary atomic services as well as the invocation of outsourced services from other providers (bottom-level), the internal engineering, management and orchestration of those services (middle-level), and the presentation and provision of service(-bundles) to either consumers or other providers (top-level). The *common-mapping-level* connects providers on different hierarchy levels with each other, or the top-level of the providing party with the bottom-level of the invoking party, respectively. The canonical schema as well as the service metadata management of a service network can be implemented on the common-mapping-level. It contains the commonly shared service standard (e.g. description, interfaces, etc.). Composition on this level is not allowed. It enables only 1:1 connections between two providers. It can be created either bilateral (between two providers) or (pre-)specified by a third party (e.g. LI) or service system.

An example with 2 levels of hierarchy can be seen in Figure 6.1. Bottom-level of the LSP hierarchy contains elementary logistics functions that are bundled to composite functions by each LSP and offered as logistics services to the integrator. Those services are subscribed to the service catalog of the service map (that could be located on the common-mapping-level) and are now available to the LI (on its bottom-level) to be combined with each other (on the LI's middle-level) in order to create complex logistics services in accordance with individual customers' demands (on LI's top-level).

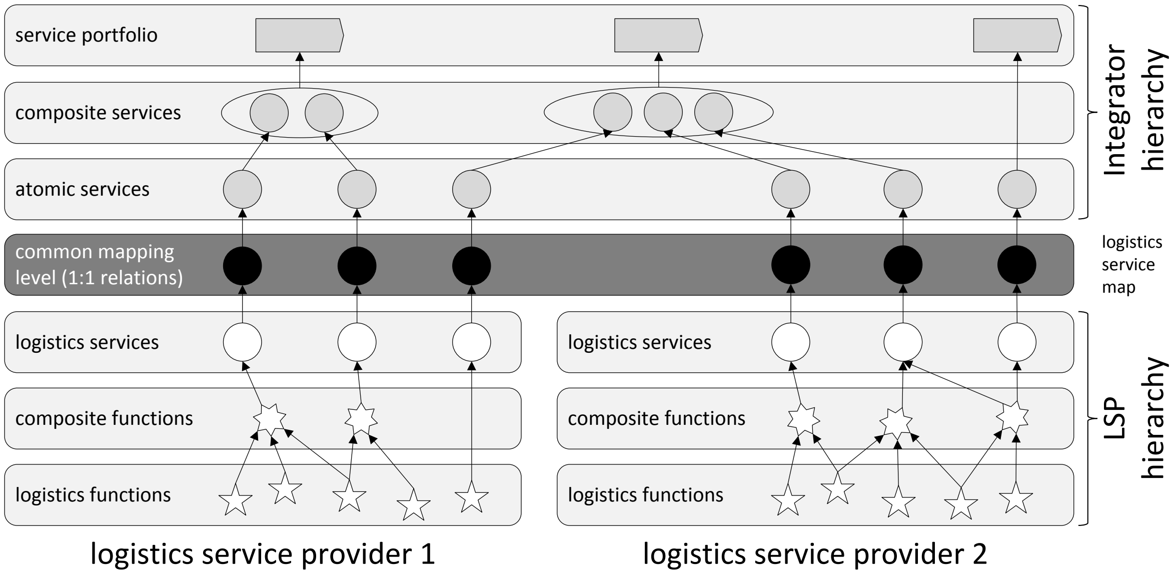

Figure 6.1: Service granularity framework applied to the example logistics service network.

In terms of contribution type level (see Table 1.2) and the kind of knowledge contribution (see Table 1.9), the artifacts of the paper can be characterized as follows: The conceptualization of service granularity, and the definition of granularity concepts and levels are the first in depth examination with the different aspects of service granularity. It is being discussed in literature as a point of compromise in service engineering, and partly focused on in terms of mathematical description of the amount of functionality bundled within one service. However, the missing comprehensive conceptualization has not been articulated as a problem in literature before. Hence, the problem as well as the solution maturity are low, and the resulting knowledge contribution of the service granularity framework is an invention. The framework can be applied to a certain range of problems and thus is located on the second level of contribution types.

This papers acts as a connector between the engineering of cloud logistics services ("service landscape", i.e. description of atomic services invoked from LSP by the LI) and management of cloud logistics servcies ("service map", i.e. the creation of composite services according to customer demands by the LI). The results are further used for the consolidation and research roadmap (#8).

7 Prototype

Glöckner, Michael; Niehoff, Tim; Gaunitz, Benjamin; Ludwig, André (2017): Logistics Service Map Prototype. In: Mädche, Alexander; Vom Brocke, Jan; Hevner, Alan (Ed.) Designing the Digital Transformation - Design Science Research in Information Systems and Technology, 12th International Conference, DESRIST 2017, Karlsruhe, Germany, May 30 – June 1, 2017, Proceedings. In: Lecture Notes in Computer Science, Vol. 10243. Springer International Publishing. Pp 431-435. [Glöckner, Niehoff, et al., 2017]

7.1 "Logistics Service Map Prototype"

Table 7.1: Meta data of the publication (Prototype).

DOI	10.1007/978-3-319-59144-5_26
URL	https://link.springer.com/chapter/10.1007/978-3-319-59144-5_26
Type	Conference Paper, Book Chapter
Publication in	12th International Conference on Design Science Research in Information Systems and Technology, DESRIST 2017, Karlsruhe, Germany, May 30 - June 01, 2017, Proceedings
Editor	Mädche, Alexander; Vom Brocke, Jan; Hevner, Alan
Series Title	Lecture Notes in Computer Science (LNCS)
ISSN / ISBN	0302-9743 (ISSN), 978-3-319-59144-5 (ISBN)
Publisher	Springer International Publishing
Place of Publication	Karlsruhe, Germany (DESRIST 2017); Switzerland (Journal)
Ranking	CORE: A-ranked (conference) VHB: C-ranked (proceedings) h-index: 251

Logistics Service Map Prototype

Michael Glöckner[1(✉)], Tim Niehoff[1], Benjamin Gaunitz[1], and André Ludwig[2]

[1] Leipzig University, Leipzig, Germany
{gloeckner,gaunitz}@wifa.uni-leipzig.de, niehoff@studserv.uni-leipzig.de
[2] Kühne Logistics University, Hamburg, Germany
andre.ludwig@the-klu.org

Abstract. Concentration on core competencies in logistics requires collaboration between logistics service providers in order to fulfill complex customer demands. The increasing demand for flexibility in logistics is facing the heterogeneity of the providers. This creates a challenging field for planning complex supply chains. Logistics integrators are meeting this challenge. One main issue is the retrieval of the services available in the logistics network and their combination for planning complex supply chains. The prototype presented in this paper supports the retrieval by providing a customizable domain-specific dimension concept for structuring services. With the help of the dimensions and a customizable domain-specific template scheme, a dynamic matrix is created in order to facilitate the retrieval of services matching the selected dimensions. After retrieval, the services can be combined on a canvas via drag and drop in order to plan complex services and simultaneously create both their BPMN diagram and corresponding XML file.

Keywords: Logistics service map · Prototype · Service engineering · Service management · Cloud logistics

1 Introduction

The paradigm of cloud logistics [1] focuses on the combination of logistics services of different logistics service providers (LSP). Based on the concentration on core competencies [2], LSPs have to collaborate in order to fulfill complex customer demands [3]. With a high demand for flexibility on the customer side [4] and a high heterogeneity on the provider side [5], the business model of a 'logistics integrator' (LI) [6] is required to solve the resulting field of tension. Main tasks of the integrator are the retrieval of services available in the logistics network and their combination for planning complex supply chains. Due to the heterogeneity of the services and their description, a common framework requires a high degree of customization. Further, a domain-specific categorization scheme for the structuring of the services is needed in order to facilitate retrieval of suitable services during the planning phase. These issues are taken into account by the *Logistics Service Map* (LSM) [7]. As the LSM is only realized on a conceptual level, this paper's contribution is the incremental advancement of a prototypical implementation by answering the following research question: *How can the concept of the Logistics Service Map be implemented prototypically?*

A. Maedche et al. (Eds.): DESRIST 2017, LNCS 10243, pp. 431–435, 2017.
DOI: 10.1007/978-3-319-59144-5_26

2 Logistics Service Map Prototype Description

The LSM prototype mainly comprises a single page web application for the collaboration of an LI and several LSPs. Customizable concepts of structuring and visualization support the engineering and management of the logistics services that are available in a logistics network. In addition to the rather literature-based functional requirements presented in [1] and the further publications cited therein, the list of features was extended by empirical-based requirements. Through workshops with LSP from a logistics network prior to the development of the prototype, several features were added. Main features are the engineering of *service templates* that constitute the origin of *services*. The customizable concepts of service templates and *dimensions* are used to structure services. The management and retrieval of services is realized through a *matrix* as a visual structured representation that dynamically takes the structuring concepts into account and facilitates the retrieval of services. The function of combining several services to engineer complex logistics services is essential to the service map concept. Empirical findings suggested *Business Process Management Notation* (BPMN) to be the favored way of presenting complex services that shall be used afterward for process management in the network.

Cooperation with regard to the exchange of information is facing several issues, such as the LSPs' heterogeneity of IT systems and service description. The LSM prototype solves this issue by providing a web application, i.e. *cross-platform solution*, that all network participants can use. Further, different quality levels of service descriptions are an issue. Information gaps can occur that complicate picking the most suitable services for customers' demand. The LSM prototype addresses this issue by a shift of responsibility. The LI can create *service templates* for certain types of services, e.g. transportation service, with mandatory and optional attributes. LSP that want to offer their logistics service through the LSM chose a suitable template and fill in at least the mandatory information, e.g. mode of transport, area, and range, in order to make their capability available as a *service* in the LSM. After filling in the attributes, a new service (e.g. transportation) is created and stored in the database. Hence, quality standards of the service descriptions can be achieved with regard to the requirements of the LI. The LSM prototype aims at supporting the management of the logistics services offered by the participating LSPs. In order to keep track of a possibly large amount of services, the LSM features a domain driven structuring of services in order to support filtering and visualization of services. For this issue, the prototype contains a resource named *dimension* that represent one possible aspect of *services* (e.g. region of provision, range of distance). With this, the service can be sorted by distinct inherent attributes (e.g. Europe, long distance). The *matrix* is a table created by selecting two *dimensions* and certain templates as filters in order to narrow the selection. Underneath the matrix, a *BPMN canvas* is integrated. The LI can transfer services from the matrix onto the canvas easily via drag and drop. *Complex service* that consists of multiple services can be built, while simultaneously a BPMN diagram and its corresponding XML file are created for further use in other contexts.

The described features and resources can be seen in Fig. 1. The LI, who manages the network and plans the supply chains, is in charge of creating *dimensions* and *service templates* that fit the network's character and the planning style. Afterward, LSPs willing to participate in the network and the inherent supply chains are able to create and submit their *services* to the LSM with the help of mentioned resources. During planning phase, the LI is able to filter and visualize the available submitted services with the help of the *matrix* and to create complex service (in BPMN and XML) with the help of the *BPMN canvas*.

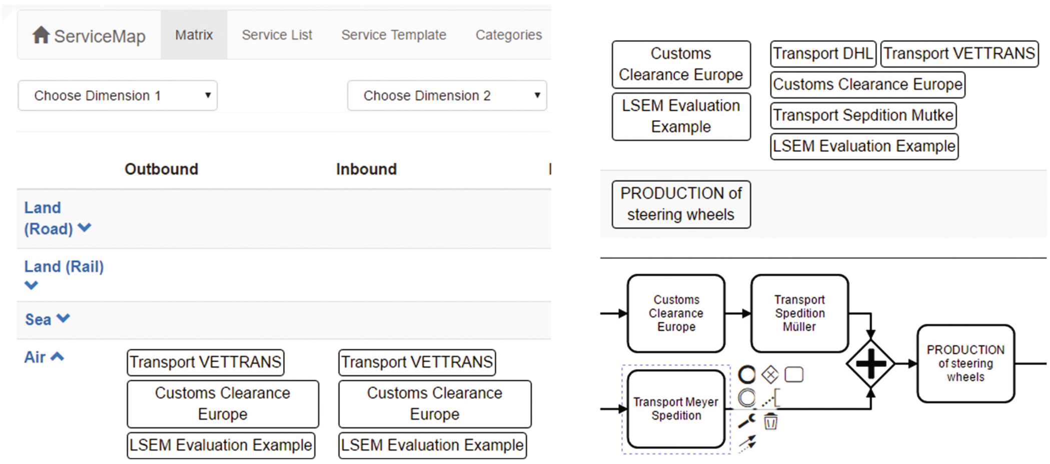

Fig. 1. Screenshot with parts of the prototype. On the left, from top to bottom, are the navigation bar, the *dimension* selection and one top piece of the *matrix* with the *services* represented as radiused rectangles. On the right, from top to bottom, are the bottom piece of the *matrix* and the integrated BPMN editor canvas underneath.

In addition to the identified requirements and features, further non-functional requirements, such as fast development, easy maintenance and customization are defined. Consequently, the *MEAN stack* paradigm [8] is applied to develop the web-based application. This comprises the embedded components MongoDB, Express, AngularJS and Node.js, each supporting Javascript as a single programming language for the whole stack and thus, allows fast development. While MongoDB offers a NoSQL document store to save all the resources, (i.e. services, service templates, and dimensions), the purpose of AngularJS as a front end framework is to build a single page application providing the user interface. In the prototype, Node.js helps to build a back end web server offering a RESTful API along with its framework Express. Thus, a light way of communication between the client and the back end database can be established.

The front end contains three modules to manage the resources, i.e. dimensions, service templates, and services. Each of them features a view to list all resources of the same kind as well as a view to create, update, observe and delete single resources. During creation of service templates it is possible to add mandatory and optional attributes for the creation of services based on these templates as well as the data types of the attributes, i.e. strings, numbers, boolean (via check-boxes and radio-buttons). Further, the prototype allows to inherit attributes, and their state of being mandatory or not, from more general service templates to more specific ones, e.g. attributes from 'transportation service template' are inherited to 'express transportation service template'. During creation of a service, it is necessarily assigned to one of the provided service templates. Thus, all corresponding attributes of the template are shown to the LSP and have to be filled in if mandatory. Before saving a service to the database, required attributes and their data types are validated. In the fourth front end module, the LI can select two dimensions and optionally a certain service template in order to filter services to be displayed in the matrix, see Fig. 1. In addition, the matrix page includes a canvas underneath that comes from bpmn-js as a Javascript rendering framework and web modeler for BPMN 2.0 [9]. The user is able to drag and drop services from the customized matrix onto the canvas directly as BPMN tasks in order to create complex services as BPMN 2.0 processes. After editing, they can be stored as (complex) services in the database based on their XML code and be converted to a sub-process that is reusable in the canvas again for creating even more complex services. A demonstration of the prototype client can be found on the website: https://lldevelopment.wifa.uni-leipzig.de:8093.

3 Evaluation, Significance of Results, and Outlook

The Framework for Evaluation of Design Science Research (FEDS) [10] was applied to the created artifact. Goal is to show its usefulness with the help of a 'Quick & Simple' strategy. The evaluated properties, which have been chosen to be proved by a group of logistics experts, are usability, flexibility, and comprehensibility. The group of four experts had to model logistics services given by written service descriptions and to create a complex logistics service consisting of some of the given services. Finally, an XML file of the complex service for BPMN had to be produced. The evaluation group rated the properties to be fulfilled partly as *comprehensibility* was marked to have further potential. This resulted from the fact that the users first had to acquaint themselves with the structuring approach of the features template, dimension and category. After explaining the features, the properties *flexibility* and *usability* of the prototype were rated high. As a consequence, a detailed documentation of the several features and modules of the prototype and their relations was created in order to improve the comprehensibility of the prototype.

As the paradigm of cloud logistics is not a widespread field of research [1], such a prototypical implementation is an innovative artifact for the research community that enables researchers to conduct further field experiments. Several domain-driven structuring approaches and template variants can be analyzed towards their suitability from a empirical perspective. With the high evaluation of the properties flexibility, usability as well as with the fulfillment of the functional requirements (i.e. the support of engineering and management of simple and complex logistics services from heterogeneous sources) a high significance to practice is confirmed. Especially, the functions of structuring, retrieval and combination of logistics services and the subsequent creation of BPMN graph and XML for further usage are fulfilled. LSP can benefit from such an artifact by a common standard in logistics network that enbales them to collaborate easily. LI benefit from an increased speed of engineering different process alternatives.

Future work comprises multi-user features like authentication or assignment permissions and the automatic creation and structuring of logistics service from electronic description. Eventually, the full integration of the prototype into the logistics service platform of the main research project LSEM is planned.

Acknowledgment. The work presented in this paper was funded by the German Federal Ministry of Education and Research within the project *Logistik Service Engineering und Management* (LSEM). More information can be found under the reference BMBF 03IPT504X and on the website http://lsem.de/.

References

1. Glöckner, M., Ludwig, A., Franczyk, B.: Go with the flow - design of cloud logistics service blueprints. In: Proceedings of the 50th Hawaii International Conference on System Sciences (2017). doi:10125/41776
2. Langley, J., Long, M.: 2017 third-party logistics study: the state of logistics outsourcing: results and findings of the 21st annual study. In: Annual Study of Capgemini, Pennstate and Penske (2017)
3. Subramanian, N., et al.: 4th party logistics service providers and industrial cluster competitiveness. Ind. Manag. Data Syst. **116**(7), 1303–1330 (2016). doi:10.1108/IMDS-06-2015-0248. ISSN: 0263–5577
4. Esmaeilikia, M., Fahimnia, B., Sarkis, J., Govindan, K., Kumar, A., Mo, J.: Tactical supply chain planning models with inherent flexibility: definition and review. Ann. Oper. Res. **244**(2), 407–427 (2016)
5. Franke, M., Becker, T., Gogolla, M., Hribernik, K.A., Thoben, K.-D.: Interoperability of logistics artifacts: an approach for information exchange through transformation mechanisms. In: Freitag, M., Kotzab, H., Pannek, J. (eds.) Dynamics in Logistics. LNL, pp. 469–479. Springer, Cham (2017). doi:10.1007/978-3-319-45117-6_41
6. Jager, K., Ujvari, S.: Hilmola: Operating as a thirdparty logistics integrator without any distribution operations ownership. Int. J. Serv. Standards **3**(2), 154–168 (2007). doi:10.1504/IJSS.2007.012926. ISSN: 1740–8849
7. Glöckner, M., Augenstein, C., Ludwig, A.: Metamodel of a logistics service map. In: Abramowicz, W., Kokkinaki, A. (eds.) BIS 2014. LNBIP, vol. 176, pp. 185–196. Springer, Cham (2014). doi:10.1007/978-3-319-06695-0_16
8. Holmes, S.: Getting MEAN with Mongo, Express, Angular, and Node. Manning Publications, Shelter Island (2016). ISBN: 1617292036
9. Camunda: bpmn-js. BPMN 2.0 rendering toolkit and web modeler (2016). https://bpmn.io/toolkit/bpmn-js/
10. Venable, J., Pries-Heje, J., Baskerville, R.: FEDS: a framework for evaluation in design science research. Eur. J. Inf. Syst. **25**, 77–89 (2016). doi:10.1057/ejis.2014.36. ISSN: 0960–085X

7.2 Executive Summary

The paper describes and presents the incremental advancement of a *prototypical implementation* of the service map that facilitates the engineering and management of cloud logistics service. The leading design method is prototyping [Wilde and Hess, 2007; Lantz, 1986]. The paper answers RQ_6 (see Section 1.2).

The prototype's objective is the proof-of-concept of the cloud logistics approach. It enables the engineering of logistics service templates. Those templates are the basis for the creation of services and form the foundation of the service catalog structure. Two of the catalog's structure dimensions can be applied at the same time to a dynamic matrix in order to structure services, visually represent them to the user and thus, facilitate service retrieval (see Figure 7.1). The demanded services can be transferred from the matrix via drag & drop onto a Business Process Model and Notation (BPMN) canvas. While being dropped, the services are automatically transformed into BPMN tasks. By connecting the BPMN tasks with each other, composite services are created that are simultaneously saved as BPMN diagrams and Extensible Markup Language (XML) documents as well (see Figure 7.1). Hence, machine readable documents and processable service descriptions are created. Those processable service description are the basis for concrete service instances that are operated in the logistics network. The prototype is realized following the MEAN stack paradigm [Holmes, 2016]. With the unique programming language javascript for all parts of the prototype, e.g. MongoDB as the document store, Express as the client web framework, node.js as the server web framework, and angular as the single-page-web-application front end, the solution can be easily implemented and maintained in a cloud environment.

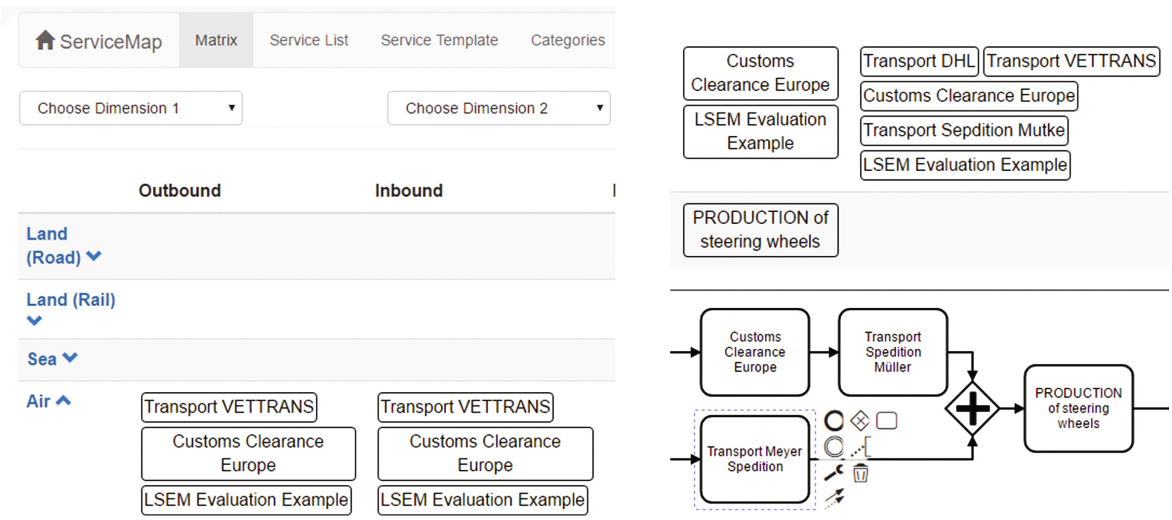

Figure 7.1: Screenshot with parts of the prototype. On the left, from top to bottom, are the navigation bar, the dimension selection and one top piece of the matrix with the services represented as radiused rectangles. On the right, from top to bottom, are the bottom piece of the matrix and the integrated BPMN editor canvas underneath.

The prototype artifact can be characterized as a situated implementation of artifact, i.e. level 1, for explanation see Table 1.2. In terms of knowledge contribution (see Table 1.9), the prototype can be characterized as an exaptation since the solution itself (MEAN Stack javascript application) is taken from the field of IT and applied to the problem of the logistics service map in the context of cloud logistics. As the proof-of-concept, the prototype constitutes one important point of evaluation [Gregor and Hevner, 2013].

This papers is the proof-of-concept for the engineering and management of cloud logistics service. It is based on the findings of papers #1 - #4. The results are further used in the consolidation and research roadmap (#8).

8 Application

Glöckner, Michael; Mutke, Stefan; Augenstein, Christoph; Ludwig, André (2015): Planning of Composite Logistics Services: Model-Driven Engineering and Evaluation. In: Hammoudi, Slimane; Maciaszek, Leszek; Teniente, Ernest; Camp, Olivier; Cordeiro, José (Ed.) Enterprise Information Systems - 17th International Conference, ICEIS 2015, Barcelona, Spain, April 27-30, 2015, Revised Selected Papers. In: Lecture Notes in Business Information Processing, Vol. 241. Springer International Publishing. Pp 364-384. [Glöckner, Mutke, Augenstein, et al., 2015]

8.1 "Planning of Composite Logistics Services: Model-Driven Engineering and Evaluation"

Table 8.1: Meta data of the publication (Application Example).

DOI	10.1007/978-3-319-29133-8_18
URL	https://link.springer.com/chapter/10.1007/978-3-319-29133-8_18
Type	Conference Paper, Book Chapter
Publication in	17th International Conference on Enterprise Information Systems, ICEIS 2015, Barcelona, Spain, April 27-30, 2015, Revised Selected Papers
Editor	Hammoudi, Slimane; Maciaszek, Leszek; Teniente, Ernest; Camp, Olivier; Cordeiro, José
Series Title	Lecture Notes in Business Information Processing (LNBIP)
ISSN / ISBN	1865-1348 (ISSN), 978-3-319-29132-1 (ISBN)
Publisher	Springer International Publishing
Place of Publication	Barcelona, Spain (ICEIS 2015); Switzerland (Journal)
Ranking	CORE: C-ranked (conference) VHB: C-ranked (proceedings) h-index: 27
other	The conference version of the paper [Glöckner, Mutke, and Ludwig, 2015] received a Best-Paper-Award at ICEIS 2015: http://www.iceis.org/PreviousAwards.aspx#2015

Planning of Composite Logistics Services: Model-Driven Engineering and Evaluation

Michael Glöckner[1](✉), Stefan Mutke[1], Christoph Augenstein[1], and André Ludwig[2]

[1] Leipzig University, Grimmaische Straße 12, 04109 Leipzig, Germany
{gloeckner,mutke,augenstein}@wifa.uni-leipzig.de
[2] Kühne Logistics University, Großer Grasbrook 17, 20457 Hamburg, Germany
andre.ludwig@the-klu.org

Abstract. Tactical planning of composite services in heterogeneous logistics networks is facing two major problems. First, existing planning methods lack in concreteness as they instruct to compare different alternatives of possible composite services in order to find the best solution, but they do not state how to develop and engineer those alternatives. Second, the planning and evaluation of composite services via simulation is difficult, because services are offered and processed by different logistics service providers of the network and thus are based on different information sources and different kind of models. In this paper both issues are addressed with a comprehensive method. Engineering is supported by the service map that is an electronic catalog and construction system for services to create alternatives of process models from composite services automatically. Evaluation is assisted by an automated transformation of process models to simulation models. Information exchange between both concepts is realized with a model-driven integration approach.

Keywords: Logistics · Planning · Model-driven · Process alternatives · Engineering · Evaluation

1 Introduction

Logistics focuses on planning, operating and monitoring systems that comprise material flow as well as the related information flow [1]. Resulting from the common paradigms of division of labor and outsourcing, a high number of participants within logistics systems arises. Each of them maintains a wide range of IT-systems as well as a wide range of services with differing provider-specific descriptions [2]. This complexity is difficult to handle, e.g. see [3,4], in order to negotiate and fulfill specific and individual logistics contracts. Especially, the planning phase of a logistics system forms the basis of all future operations and system's results. This fact implicates a challenging issue that arises from the high amount of stakeholders, services, their descriptions and possible combinations.

Planning is generally differentiated into the commonly accepted classification of strategic (long-term), tactical (mid-term) and operational (short-term)

S. Hammoudi et al. (Eds.): ICEIS 2015, LNBIP 241, pp. 364–384, 2015.
DOI: 10.1007/978-3-319-29133-8_18

planning [5]. Tactical planning in logistics is typically situated in the competence area of central logistics departments [5], which could also be outsourced to and represented by a central logistics integrator (e.g. fourth party logistics service provider [6,7] or lead logistics provider), while actual operation and physical movement of goods is carried out by subsidiary logistics service providers (LSP) [8,9]. Tactical planning in logistics addresses the flexibility of processes (volume, delivery and preconditions of operation) as well as supply chain design, relationships and inter-organizational information systems [4,10,11]. The term flexibility means the ability to be easily modified by maintaining and analyzing a variety of alternatives in order to choose the best for a specific task under current conditions [12]. In summary, tactical planning in logistics focuses on the *engineering* of available process alternatives and their *evaluation* [10].

When analyzing the applied methods of tactical planning in logistics, literature provides a wide range of publications addressing this specific topic, see e.g. [1,10,13,14]. Consensus of all approaches is a planning procedure subdivided into several distinct phases, whereas there are different numbers of phases and aspects to be considered in each approach. Further consensus could be found in a non-linear phase-sequence as iterative loops are allowed and encouraged in order to develop appropriate solutions. Another important similarity - as already pointed out - is the development of distinct planning alternatives and the subsequently evaluation of each in order to either approximate the current solution towards an optimum or to find the best solution to a given task. However, a common shortcoming of planning methods is an inadequacy in a specific description on how to create and evaluate process alternatives.

Especially, tactical planning - as the foundation of flexibility - in the field of transport and distribution is underrepresented in research [10]. Further, the related adaptable IT is important for inter-organizational information linkage [4,12]. This leads to additional difficulties as a variety of annotations and modeling methods exists next to the variety of IT-systems of the LSP. Hence, the paper focuses on fostering tactical planning issues on IT-level. Since tactical planning lacks in a concrete method for the development of different alternatives and this issue is an essential aspect for flexibility, an approach is needed that supports the finding and subsequent evaluation of alternatives. A comprehensive overview for logistics integrators of currently available alternatives of services and processes in the network is needed to develop a wide range of potential solutions. Due to a high number of participants and their diverse approaches for service description within an open logistics network [2,9], a suitable solution for engineering and evaluation of composite services and the resulting processes within the heterogeneous LSP-landscape (and their related service descriptions and IT-systems) could be found in a model-driven approach.

The paper's contribution is a method for linking engineering and evaluation of process alternatives to support logistics integrators. After presenting the basic concepts in Sect. 2, a model-driven approach is introduced in Sect. 3 that focuses on their combination using a common metamodel. The developed method for engineering and evaluation in Sect. 4 and a summary with future research prospects in Sect. 5 conclude the paper.

2 Basic Concepts

With the issues in mind (engineering and evaluation of alternatives), the following section first introduces an approach of a combined catalog and construction system (the logistics service map) for engineering and afterward focuses on simulation in logistics as an approach for the evaluation of composite service alternatives.

2.1 Logistics Service Map

The challenge of retrieving appropriate services with heterogeneous descriptions from different IT-systems [2] that arise from a complex logistics network with numerous participants demands a solution that is commonly accepted by all network participants. Those challenges create the requirement of presenting the services of a network in a common way (catalog function) and combining them in order to form composite services (modular service construction system function). This issue can be solved by the concept of the service map (SM).

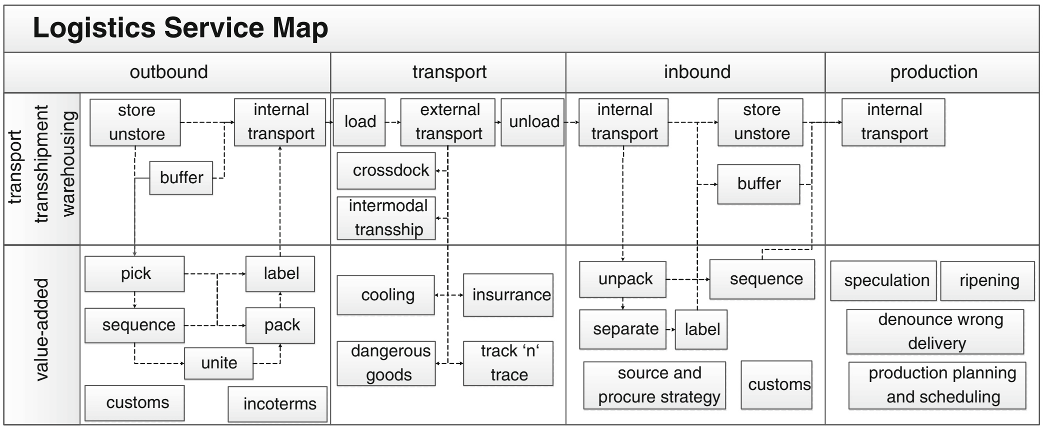

Fig. 1. Exemplary catalog-part of the SM with two dimensions: 'classic logistics function vs. value-added' and 'stage-specific'. Dashed arrows mark compatible services for composition.

The concept of the SM addresses the challenges by combining these two functions [15]. On the one hand, a catalog of all available services and process activities is provided. Every network participant has to subscribe its services to this catalog in order to have a commonly used single point of truth. With these characteristics the SM covers the conceptual functionality of a service repository. Though, to increase usability, the overview could be categorized by the user's needs in different abstraction layers. As shown in Fig. 1, a graphical representation with two spatial dimensions for the user-chosen categories simplifies the interaction for users when searching for services or process activities. In that way, service retrieval is enhanced and can be done in an intuitive way. Besides the intuitive manual usage, the catalog function also fosters a systematic categorization for (semi-)automated retrieval of atomic services. On the other hand, the concept includes a modular service construction system in order to combine atomic services to composite services. Through combination, service descriptions of the composite services are derived so that they could be transformed into process models later on for, e.g. collaborative planning in networks, simulation or mediation. With this approach, the network participants are supported in retrieving services in different use cases. (1) Adding a new service provider to the network and matching its offered services to the existing set of services in a logistics network by adding the new service provider to the provider list of the particular existing services. (2) Developing a new composite service to meet a specific customer's need by selecting and composing appropriate services from the SM. Service-specific information and attributes can be displayed when changing the selected granularity to a more detailed level to foster engineering and management. Moreover, the unique standard of the used set of services within a network and the visualization foster a precise mediation and communication between all stakeholders during the whole service life-cycle. (3) Finding compensational service or provider when realizing the urgency for re-planning or elimination of errors because of unpredictable disturbances in the network or an insufficiency in solving a given task. By analyzing the category of a distinct service that is to be replaced, a similar service with similar capabilities can be found automatically. Summarizing, the SM is capable of representing and creating planning alternatives.

Literature provides a wide variety concerning the SM concept. Either (a) the term 'service map' is used and also the functionality meets partly the requirements mentioned above, e.g. [16–19], or (b) the term is used but a different substantial functionality is addressed, e.g. [20] or (c) the term is not used but the described concept partly includes functionality for the mentioned purpose, e.g. [21,22]. Collectively, none of the approaches comprise both functionalities of catalog and construction system. As the SM concept comprises both, its functionality enables the engineering of services for a later combination to more complex processes. Hence, the creation of composite service alternatives could be realized with the use of this concept.

2.2 Simulation in Logistics

The planning of composite logistics services is performed using several different models (e.g. process model, service profile, and simulation model). A rough plan, including each sub-service and their temporal dependencies, is represented by a process model. Based on this, dynamic aspects of logistics systems can be analyzed using simulation. The main task of simulation in logistics is studying the behavior of composite logistics services (e.g. lead times, transport volumes and capacities) to ensure that customers' requirements can be met. Thus, it is possible to analyze the flow of goods through the logistics system with regard to the capacity to identify bottlenecks at an early planning stage. As a result, simulation models of logistics networks can be used to evaluate different composite service alternatives or process alternatives, respectively and consequently can improve the decision-making process in tactical logistics planning. Especially, discrete-event simulation (DES) is appropriate to enhance decision support in the planning process by analyzing several system configurations, which differ in structure and behavior [23]. However, the use of simulation also leads to a number of problems.

As mentioned previously, different models (process model, provider models and simulation model) are used within the planning process. This is a major problem because each time a model is slightly modified, any of the other related models must also be revised. As already outlined in the introduction, the modeled information itself could also differ from one provider to another whereby a wide range of descriptions and used annotations arises within a network with a high number of participants. This increases the modeling effort. Further, building simulation models requires special training and experience in order to avoid errors. It is a methodology that is learned over time. Consequently, the creation and analysis of simulation models could be expensive while consuming an enormous amount of time. This can lead to a non-profitable use of simulation [24]. As a consequence, the effort for the development of simulation models has to be reduced. In terms of planning logistics systems several models are used. These models build upon one another and show dependencies among each other. A change in a model also implicates and claims changes in subsequent models. To ensure the interaction between simulation and other models, simulation techniques have to be well-integrated in the planning process [25]. It is necessary that the created process models within the planning process, based on a separate description of each logistics service, can be transformed automatically into a simulation model. Accordingly, an approach to combine different heterogeneous planning models in order to force the reuse of already modeled information is needed. This requirement aims to minimize the planning effort of a logistics integrator by reusing already modeled information. In addition, manual errors in the creation of a simulation model are avoided. Furthermore, the need for special training and special experience in simulation model building is reduced.

In this section an approach is presented to transform process models into simulation models in order to reuse already modeled information and thus reduce modeling effort. Related work is presented by describing different simulation approaches that have influenced the development. Simulation is widely used in the field of logistics in order to plan logistics systems. Ingalls discusses the benefits of simulation as a method of studying the behavior of logistics networks [26]. Additionally, advantages and disadvantages are illustrated for the analysis of supply chains with the use of simulation. A concrete simulation approach is not provided. In [27], a commonly applicable simulation framework for modeling supply chains is presented. Contrary to [26], they focus on a more technical perspective as they show an overview of event-discrete simulation environments in terms of domains of applicability, types of libraries, input-output functionalities, animation functionalities, etc. Cimino et al. also show how and when to use certain programming languages as a viable alternative for such environments. A modeling approach and a simulation model for supporting supply chain management are presented by Longo and Mirabelli in [28]. They also provide a decision making tool for supply chain management and, therefore, develop a discrete event simulation tool for supply chain simulation. All these approaches are relevant for developing an integrated planning and simulation approach. However, all these approaches satisfy the logistics integrator's specific requirements [25] only partially. The development of simulation models based on process models is insufficiently considered.

In addition, we make use of transformation approaches for defining transformation models as a mediator between process and simulation models. In both approaches of [29,30] a transformation model is used in an additional step in order to derive a simulation model from an already existing process model. Both approaches take the fact that process models are independently defined from simulation requirements. In practice, process models serve to foster transparency or documentation and to analyze the requirements for the introduction or implementation of new information systems. However, both approaches assume that a process model is defined using Event-driven Process Chain. Cetinkaya proposes a comprehensive theoretical framework for model driven development in the field of modeling and simulation (M&S) for the efficient development of reliable, error-free and maintainable simulation models (MDD4MS framework) [31]. In a case example it is shown that MDD4MS framework is applicable in the Discrete Event System Specification (DEVS)-based discrete event simulation domain. The transformation of the Business Process Model and Notation (BPMN) elements into DEVS components has provided an effective way to easily model and simulate business processes. However, the MDD4MS framework currently provides only model transformation method from BPMN process model (conceptual modeling language) to DEVS (platform-independent simulation model) and from DEVS to Java (platform-specific simulation models). Furthermore, the required parameters for simulation were added directly to the Java code and thus can be performed by simulation experts only. Huang describes another interesting approach for Automated Simulation Model Generation [32]. The proposed method can use existing data to automatically generate simulation models. Therefore, a domain meta-model and the model component library have to be designed before the existing data can be used to provide the information about the model structure and parameterization. However, in contrast to our research the use of existing process models as source models are not considered. Nevertheless, the use of existing data for the parameterization of simulation models shows similarities to our research.

The added value of the simulation approach presented in this paper is the automatic transformation of existing process models to simulation models, as described in the following. A process model, e.g. BPMN or Event-driven Process

Chain (EPC), is simulation independent, i.e. the model does not contain any information regarding to the dynamic aspects such as arrival times, processing times or capacities. The process model is transferred into a transformation model and enriched with information required to run a simulation. However, the transformation model is platform independent and therefore cannot be executed in a specific simulation tool. The specific simulation models (e.g. Enterprise Dynamics (ED), Arena) are generated from the transformation model. The structure of the transformation model is described in more detail in [33]. Figure 2 illustrates this approach.

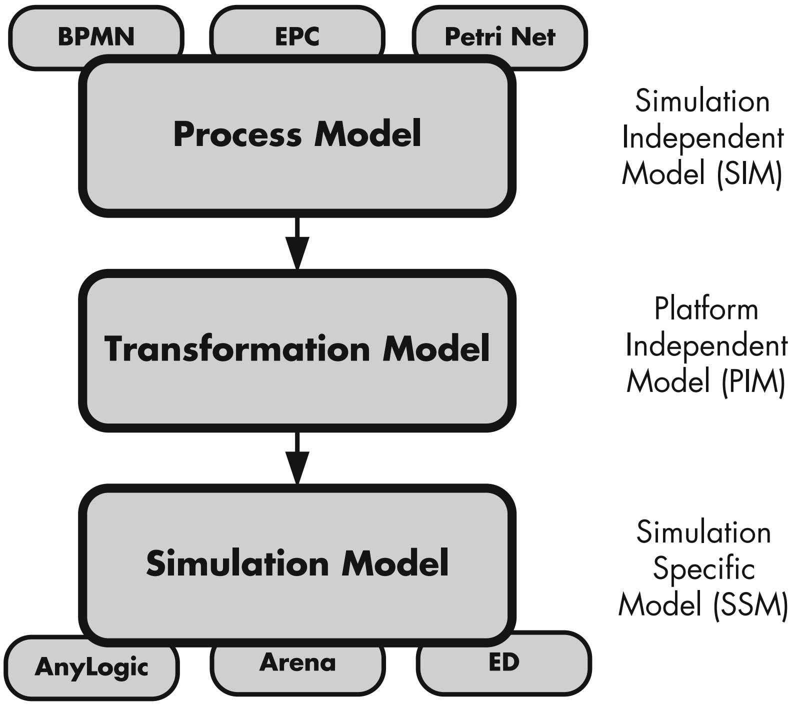

Fig. 2. Transformation approach from process models to simulation models.

Even though, simulation provides a possibility to evaluate composite service alternatives, the main problem in the current context is a dependency on process models that need to be existent before the transformation is done, in order to conduct their evaluation via simulation models afterward. Accordingly, a combination with the former presented SM concept appears to be a suitable approach for an integrated engineering and evaluation of composite service alternatives. The connection of both concepts is presented in the following section.

3 Model-Driven Connection of Concepts

The combination of these presented concepts for engineering and evaluation of process alternatives is realized by a model-driven approach. General information

gloeckner@wifa.uni-leipzig.de

about and a foundation of model-driven development and metamodeling can be found in [34]. The basic idea of this approach is to create metamodels of these introduced concepts that conform to a common metametamodel. As models are derived from those metamodels and thus conform to them as well, interconnection and data-consistency can be ensured between models with a (transitive) common metametamodel. In the beginning the general approach is introduced as well as the distinct metamodels of both concepts and at the end of the section their connection is described.

3.1 Model Integration

Models used for planning composite logistics services are designed to maintain specific information of involved services. Each planning tool has therefore a distinct metamodel as a formal base. In order to model the process of such a composite service we use, for instance, BPMN, but there is no explicit limitation in the choice of a process modeling language. Thus, during the whole process of defining a composite service, such a service is comprehensively described using various models. Dependant on the distinct modeled aspect the resulting models might then contain either disjoint or overlapping information in a sense that the same information is contained in multiple models. Since many stakeholders are involved in modeling, this situation can even get worse, when the same aspect is modeled differently by different stakeholders (e.g. using homonyms or synonyms). At the same time, we have to ensure that new modeling/planning tools can be integrated and that the overall planning, monitoring and controlling process for composite services is kept efficient. So, in our approach we foster the reuse of already modeled information and with this we are also able to avoid modeling the same aspect in different manners.

To overcome the above mentioned situation, the Service Modeling Framework (SMF) and its components [35–37] serve as a mediator and are crucial for model and information management. In SMF services are defined using a variety of models which represent certain aspects, for instance an interface or a process description, a service level agreement specification or specific characteristics in terms of runtime performance. The SMF is responsible for coping with these models, for integrating and for storing them in order to ensure consistent engineering and evaluation and thus, enables a standardized handling of service descriptions and service models. The main purpose of SMF is to interconnect all involved models on metamodel level in a such way that contained information can be extracted and reused. Each model is seen as a projection of a virtual comprehensive model within the framework. Applied to the concepts in this article, SMF is responsible for interconnecting models in the planning phase for engineering and evaluation of composite services in order to transfer information from the engineering of alternatives of composite service models to the evaluation of simulation models. SMF thus supports development of a proper simulation model from a initially developed composite service model.

3.2 Service Map Metamodel

The SM supports the categorization and development of services. Instances of the SM can be derived by the logistics integrator from the metamodel to describe specific distinct service catalogs of a network or of different networks. The advantage of a metamodeling approach is a high abstraction that provides a high reusability in a wide range of cases and a simple interaction between several instances. The SM metamodel follows the restrictions of the service modeling framework (SMF) [36], i.e. based on the EMOF (Essential Meta Object Facility) compatible Ecore metametamodel of the Eclipse Foundation. Figure 3 shows the current version of the SM metamodel [38].

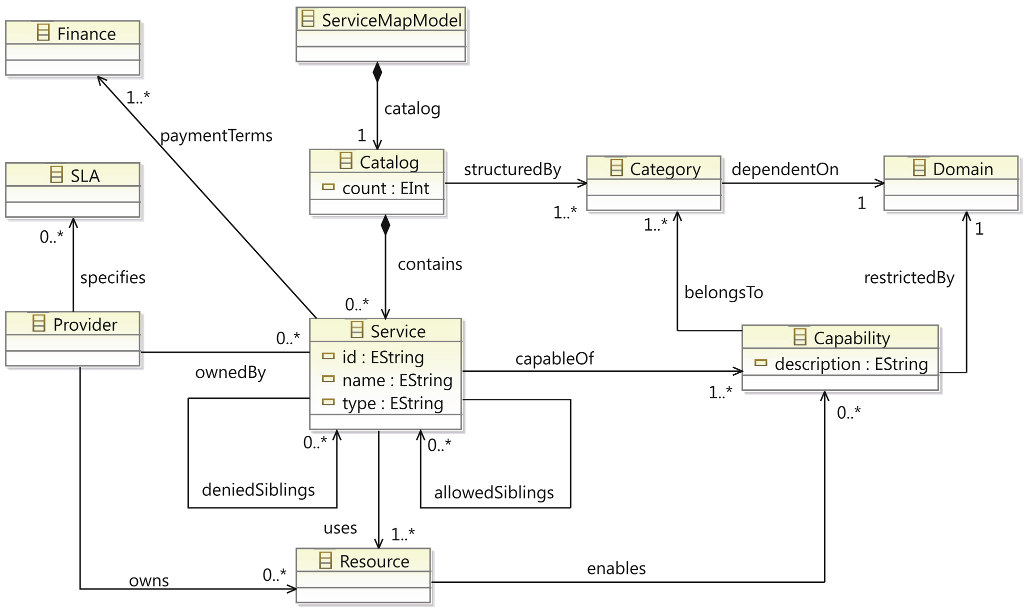

Fig. 3. Service map metamodel [38].

The following aspects are determined through the presented metamodel. Each instance of the SM metamodel consists of exactly one catalog containing services available within the network. This catalog is structured using categories that depend on a specific domain (i.e. logistics in our case). Thus, the catalog represents a structured overview of services, each capable of one or more capabilities. These capabilities belong to specific categories and are restricted by the concrete domain. On a high level, for instance, capabilities represent the ability to transport, store or to fulfill more complex composite and value adding services. In order to provide capabilities in terms of services, a provider owns specific resources like trucks or warehouses which are consumed during service execution but typically are available again afterward. Each provider is also allowed to specify zero or more service level agreements (SLA) for its services in which it specifies service level constraints and service provisioning in terms of

gloeckner@wifa.uni-leipzig.de

payment. Finally, services can either depend on other services or are restricted not to work with other services. Exemplary, restrictions for the transportation of dangerous goods could be mentioned, see [39]. Therefore, each service contains references to others which are either available for the creation of a composite service (allowedSiblings) or not (deniedSiblings).

An instance of a logistics SM thus represents a complete list of capabilities (represented by services) of the provider network, including services the integrator can provide on its own. Hence, the service map serves as a catalog of available services. Moreover, during the creation of a composite logistics service for a customer, the service map also serves as a unique point of information and as a reference for searching appropriate services and providers. This becomes apparent in the development phase in particular. During rough planning of a logistics service, the composite service has to be constructed by choosing suitable services. According to customers' requirements, appropriate providers have to be chosen for each task in the composite service. Therefore, the service map is used to identify providers who offer the needed service type and SLA. Because the logistics SM follows a metamodel-based approach, an integrator also has the ability to manage multiple provider networks independently, for instance in automotive industry. Requirements of OEMs (Original Equipment Manufacturer) are very strict as they often demand secure supply chains. Providers are not allowed to use distinct resources in different contracts. For instance, an integrator responsible for warehouses with vendor managed inventory (VMI) for multiple OEMs at nearby production sites is liable to provide warehouse resources to each of the OEM exclusively, i.e. separate infrastructure and employees, in order to keep business secrets. With this in mind, an integrator is still able to optimally allocate resources if he partitions its complete network into independent parts and manages each of them separately. Though, same services are in different catalogs, the integrator is aware of the total resources available and can create an efficient supply chain for each customer.

With the metamodel the contained information itself as well as the existing connections and attributes between several classes are structured and thus facilitate retrieval processes and allow an information based connection to other types of models or between different instances of SMs.

3.3 Generic Simulation Metamodel

The generic simulation metamodel also follows the approach of the service modeling framework (SMF) [36], i.e. based on the EMOF compatible Ecore metametamodel of the Eclipse Foundation.

In the following, the approach is described in more detail and it is shown how the generic simulation metamodel (platform independent) was created by considering the basic concepts of DES and the specific requirements from the perspective of a logistics integrator. Process models describe functional or structural aspects that are relevant for a process. Depending on the used process model notation, these functional aspects (e.g. Task in BPMN, Function in EPC, Transitions in Petri Net) represent the different partial atomic services as parts

374 M. Glöckner et al.

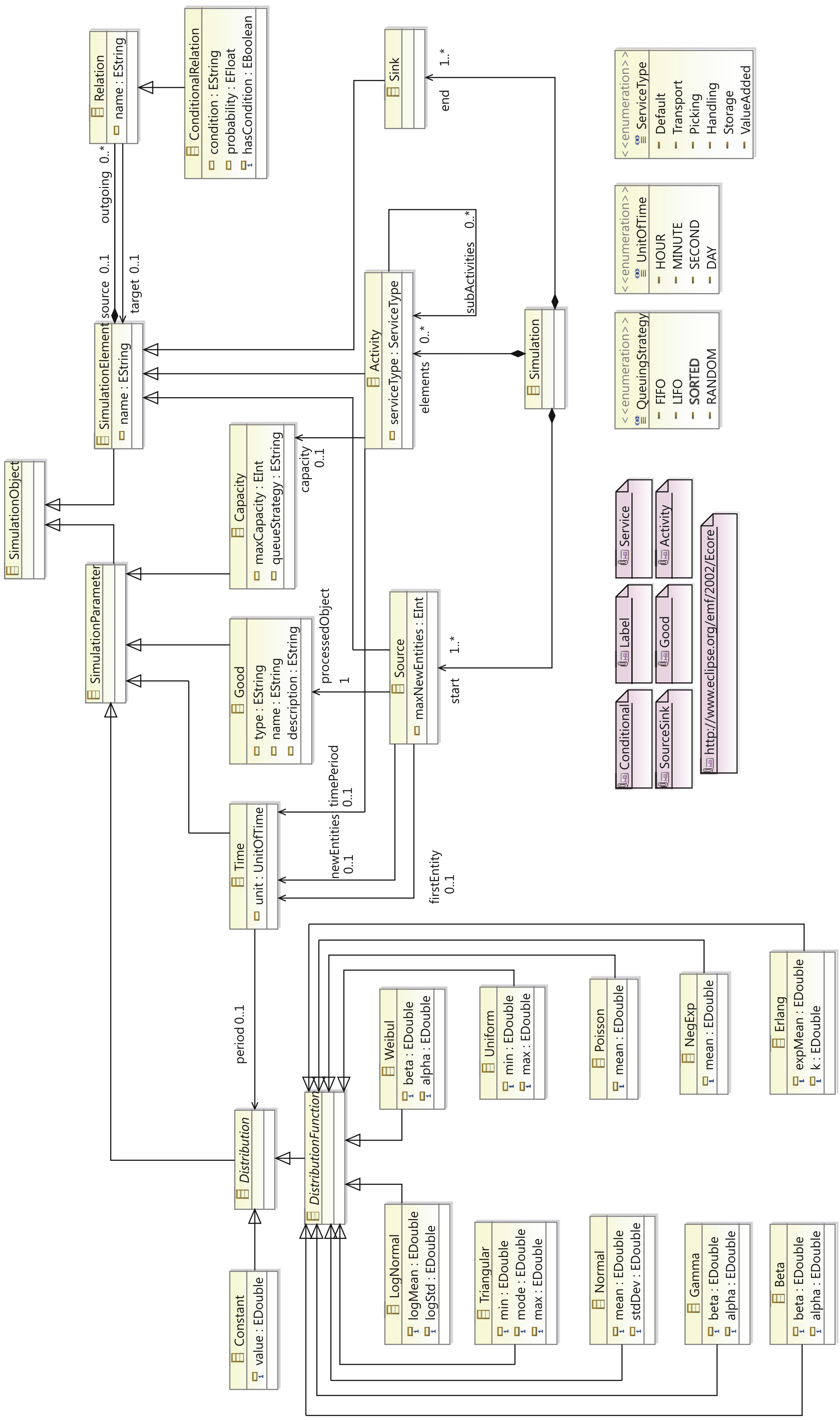

Fig. 4. Generic simulation metamodel [40].

of the composite services and processes in the scope of a logistics integrator's planning process. In [41] an approach for formal and semantic description of services in the logistics domain using concepts of service orientation and semantic web technologies is presented. The approach also categorizes and describes modular logistics services such as transport, handling, storage, value-added services, etc. using a logistics ontology. Concepts of this ontology are used in this research paper to refer to the description of specific logistics services from the functional aspects depending on the used process model language (Task, Function or Transition). Thus, each functional aspect is assigned to a specific logistics service type. Consequently, the result is a process model including all atomic services necessary to meet customers' requirements. Despite having a process model and using this model as the basis for creating a simulation model, for simulation additional information as to the pure visualization of the processes is necessary. Therefore, literature was analyzed concerning information that is additionally required to create a simulation model and relating basic concepts were derived (Entities, Events, Attributes, Activities and Delays) [40]. In addition to these basic concepts of DES, a simulation also has logistics-specific properties. Therefore, two simulation tools using an application-oriented modeling concept (ED and Arena) have been used to create different examples of simulation models in order to study transport volumes and capacities. These tool-dependent models have been analyzed and compared in terms of used modeling concepts and the required data. The common concepts of these tool-dependent models and the basic concepts of DES were used to create the metamodel shown in Fig. 4.

The generic simulation metamodel basically consists of SimulationElements, SimulationParameters and Relations. A Source generates goods at predefined time periods and they leave the model at the Sink. The purpose of an Activity is to manipulate goods in some ways, e.g. to store or to transport them. Therefore, Goods enter an activity and remain there for a certain time period. Moreover, an activity is assigned to a certain ServiceType which defines the specific functionality of this activity. These three main concepts are subsumed under SimulationElements. All Time periods can also be specified more precisely with the help of DistributionFunctions. Regarding the service type, a Capacity is an additional characteristic of an activity. For instance, an activity with the service type "warehouse service" is restricted by a maximum capacity and has a certain queuing strategy. Time, capacity, goods and distribution are subsumed under SimulationParameters. The connecting elements between the activities are represented by two different kinds of Relations. On the one hand, relations can be simple, i.e. without specific characteristics. On the other hand, a connection between activities can be represented by ConditionalRelations with additional, specific characteristics (conditions, probabilities). Depending on values of these characteristics, in a simulation either one or the other path is used. With this metamodel, it is possible to create simulation-tool-independent models, which contain all information necessary to perform a simulation. Further, a structure is built between several information aspects and thus fosters a parameter specific evaluation and improvement of processes or composite services, respectively.

3.4 Interconnecting the Models

Especially, for an efficient engineering and evaluation, services and their descriptions have to be handy in terms of analyzing and processing. The SMF editor component provides a flexible way of interconnecting models and model elements so that appropriate information is picked from the individual models and merged into a more complex service definition. To provide a basis for interconnection of service models, SMF contains a metamodel called Common Service Model (CSM, [35]). The CSM serves as a basic structure for the SMF as essential concepts in general are defined and connected to each other. It also introduces specialized elements, namely ServiceAspect and ServiceDescriptionElement, in order to connect models and their elements respectively. The CSM is also point of origin for a set of artifacts, like the SMF editor. In contrast to automated model transformation approaches, SMF relies on a descriptive, informal interconnection. Existing approaches for a model-to-model transformation connect elements from different models on metamodel level and then perform a semi-automated transformation on model level. This isn't appropriate for our approach because of the following reasons: on the one hand, transformations are realized directly and only on metamodel level. If we then wanted to add a new model type we would have to define multiple transformations for each already existing metamodel. On the other hand, transformations can only be implemented in an automated fashion by comparing the abstract syntax of a language. Very often, however, manual steps have to be added in order to make sure that the transformation is correct and complete (e.g. see the definition of extensional connections in [42] or see the definition of intermodel-correspondences in [43]). Model transformations are valuable and easy to perform if both models (source and sink) cope with the same issue (e.g. transformation of a BPMN-model into a BPEL-model). Within the SMF we, however, have to cope with models which are entirely different in scope and functionality. On a conceptual as well as technical level we use a modified version of the CSM within the editor and thus are able to model only valid relationships (in matters of SMF) between different services and their models respectively. Because the CSM is the metamodel of the editor the resulting model is thus a version of the comprehensive service model for a certain service. Later on, we can also extend this version if new service models are added to the service or if requirements changed and dependencies between models have to be updated. The comprehensive model is then used as input for an information extraction step which takes the contained models and their elements respectively and sees to transfer information into the appropriate places.

In the following it is presented by whom and how the SMF editor should be used. SMF components in general are designed for the usage at the logistics integrator's site. Participating partners like customers or LSPs are not confronted with these concepts as they are not directly involved in tasks like network management or building complex supply chains. Instead, the editor is intended for usage by logistics domain experts. They are able to analyze logistics processes and descriptions from subsidiary providers, to model information in logistics service models and therefore have deep knowledge about different model types.

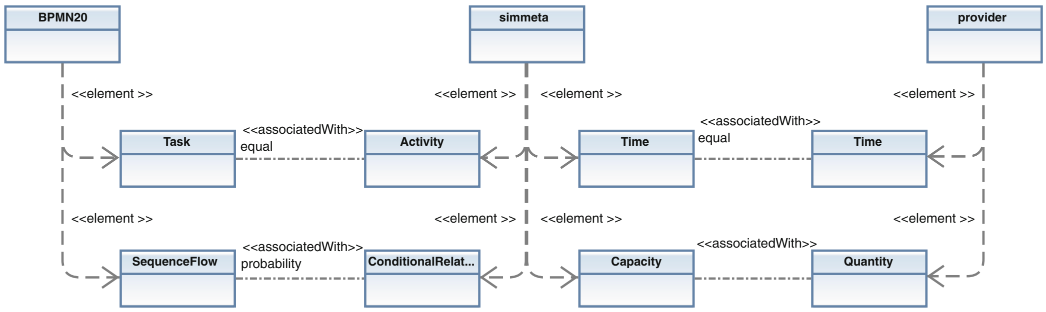

Fig. 5. SMF editor modeling (excerpt) [36].

Logistics domain experts use the SMF editor in order to identify and mark model elements of different models which contain equal or similar information.

Services and models can be dragged from a repository component into the editor and relationships can be defined as depicted in Fig. 5. Information has to be integrated from a process model ("BPMN2.0") - derived from the composite service - and from different "provider" models into a simulation model ("simmeta"). The process model is derived from the composite service built with the service map and thus conforms the service map metamodel. Simmeta equals the generic simulation metamodel. Thus, we look for elements in the source as well as in the sink models which contain equal or similar information with respect to conceptual identity. A task in a process, is e.g. semantically equal to an activity in the simulation model. Further, information from modeled sequence flows can be used in simulation. Defining such connections is repeated for each used model and the resulting service model is used as input for the extraction component of SMF which in turn is responsible for creating and updating models.

The two presented metamodels are kept simple and only consist of a few essential elements and their relationships. As both follow the SMF of [36] it is possible to interconnect elements from different models with the common service model (CSM) [35]. The CSM contains a metamodel for integration and transformation of differing models. Both models are defined through the same modeling language on metamodel-level, i.e. Ecore metametamodel. Hence, we are able to reuse information contained in these models and to easily interweave them. The metamodels are defined in Ecore but could be easily implemented in other frameworks as well. The Service is the central element of the SM metamodel. As services implicate a kind of input and output connected to a certain capability and can contain sub-services, a connection to the Activity element of the generic simulation metamodel is suggested. Hence, an interchange of information and an automated workflow can be implemented to combine engineering and evaluation of process alternatives.

4 Method Engineering

In this section a method for semi-automated engineering and evaluation is developed. The leading approach is a process model for method engineering. After

gloeckner@wifa.uni-leipzig.de

connection of the basic approaches an activity diagram illustrates the results and the contribution of this paper.

The process model for method engineering presented by Ralyté and Roland outlines two different strategies for assembling so called method components, method chunk or method fragments. Depending on the characteristics, either an *association* strategy or an *integration* strategy is proposed for assembling method components [44]. The first strategy is recommended for method components without any common elements. This case occurs e.g. when basic components are working in a serial manner, i.e. the output of one component is used as the input for another component. Thus, by associating the two initial components a method can be created that provides a larger coverage than any of the basic ones. Hence, the objective of this assembling process strategy is to *retrieve connection points* and build a bridge between them. In contrary, the latter strategy concentrates on merging overlapping elements in two components that focus on similar tasks but with e.g. different solving strategies. The range of possible results remains similar but functionality is enhanced. The focus of this assembling process strategy is the retrieval of overlapping elements in order to merge them. Consequently, the *association strategy* is suitable for the purpose of the current paper. Engineering and evaluation are two different method components that focus each on solving different tasks. Further, the output of the engineering, i.e. one or more composite service alternatives and the related process models, constitutes the input for the subsequent evaluation. The non-existence of common elements, which is to be recognized when comparing the presented metamodels, underlines the decision for the association strategy as well as the serial characteristic of the designated final functionality of the two initial components.

The figuring out of connection points for the association of the basic components is also based on the approach of Ralyté and Roland, taking [45,46] into account. Mainly, the original approach focuses on detecting semantical and structural similarities between the elements of the two components that are to be connected. By evaluating their common properties and links, several similarity measures are calculated to conduct the assembly later on. However, an adapted and, for the purpose of this paper, simplified argumentative-deductive version is used. As already outlined, the element *Activity* of the simulation metamodel comprises an input-output relation for a specific object. Further, there is the possibility of dividing activities into sub-activities and they are always restricted by a certain capacity. This complies with the element *Service* of the SM metamodel. A service also focuses on taking an input object in order to releasing a modified output object. The division into subservices or combination to composite services also complies with the activity-pendant. Finally, as a service always depends on a certain resource and those resources have inherent distinct capacities, a similarity can be detected between those aspects. As the original purposes of the two metamodels strongly differ, no other similarities can be figured out. In summary, the analysis of the both metamodels shows that the suggested possible connection point of the Activity and the Service element can be confirmed and implemented in the SMF editor.

Following [44], the "specification of method requirements" is outlined in the introduction in Sect. 1 and the "construction of the basic method components" is conducted through the cited literature of Sects. 2 and 3. Subsequently, the paper now proceeds with the "assembly" by determining the order of the components, identifying the connection point, i.e. the product of the first component that constitutes the source for the second one, and merging both. The engineering of an alternative before evaluating it implies the order of the components. Moreover, an iterative loop is obligatory until all possible alternatives are calculated. Connection point between the two components is the process model of the composite service that is the output of the construction system, as it is simultaneously the input for the transformation model for the later simulation. Information can be interchanged via the CSM. The final result is shown in Fig. 6.

The final method starts with the determination of customer requirements and the selection of the process or composite service from the repository that is to be (re-)planned. After selecting the process steps or sub-services, which are to be alternated and analyzed, the loop iteration starts. When no alternatives are available, an empty list of alternatives is presented to the user. As long as alternatives are still available, for every chosen (sub-)service all available alternatives from its category in the catalog are selected to create a new composite service in the construction system. With the derived description of the composite service, the engineering of the process alternative is conducted and a process model is created as the output of the first method component. The process model as the source of the generic simulation approach, is transformed into the transformation model, enriched with necessary simulation parameters, which could be analyzed and inserted from former operation statistics (like service profiles of [47]) to fully automate the method. Subsequently, the simulation is conducted in order to evaluate the composite service alternative. If the customer's requirements are met by the current alternative, it is added to the list that will be shown to the user later on. If not, the procedure continues without saving. If all available possibilities within one category for a specific sub-service are evaluated, the next sub-service is chosen to be alternated. After all sub-services have been alternated and all possible process alternatives have been evaluated, the final list with all alternatives, which meet the given customers requirements, is presented to the user. Sorted by its preferences (e.g. SLA, lead time, costs), the user could choose its favored alternative that is to be implemented afterward.

A simple use case could be a customer that is unsatisfied with the current performance of its supply chain that was planned by the logistics integrator. By analyzing the current performance parameters the lack in a certain transportation and a packing services is revealed. Hence, the integrator selects those services within the supply chain that are to be alternated and the resulting alternatives that are to be evaluated regarding the customers required performance parameters. Another use case could be a disturbance within a supply chain through an insolvency of

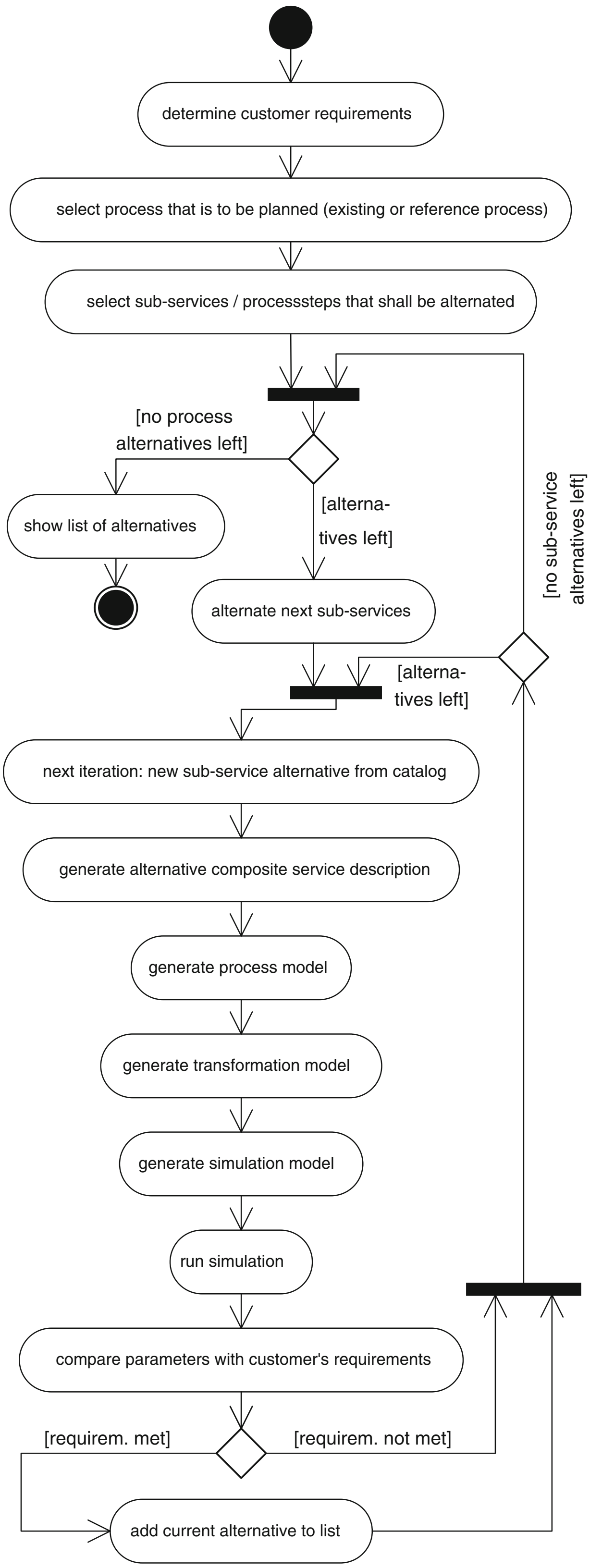

Fig. 6. Activity diagram of the resulting method.

gloeckner@wifa.uni-leipzig.de

one LSP within the network. Hence, cheap and/or reliable alternative LSPs are to be found for the affected supply chain processes.

5 Conclusion

Tactical planning of composite services in logistics networks is a challenging task because of the ongoing outsourcing trend. This results in the combination of logistics services from different LSP with heterogeneous service descriptions. This task is further complicated by the distribution of essential information to distinct models. Planning thus depends strongly on the combination of information from several sources. As current planning approaches in literature lack in a specific description on how to create process alternatives that are evaluated afterward, this paper presented a new method for automated engineering and evaluation of process alternatives in tactical logistics planning. Further, the challenging task of combining the required information from different models is solved. The method consists of two basic concepts, the *service map* as a combined catalog and construction approach for service engineering and a *generic simulation approach* for evaluation. Both concepts are designed especially for working in an environment of heterogeneous service descriptions and process models. By combining both concepts through a *model-driven approach*, the basis for interweaving the contained information is ensured. With the process model of [44] for assembling methods from sub-components, an associated method for combined engineering and evaluation of composite service is finally developed.

Academic implication of the current article is a first method towards automated and integrated engineering and evaluation of composite services alternatives or process alternatives in the heterogeneous field of logistics. Current literature about planning in logistics does only propose to create several alternatives and to evaluate them, but does not provide explicit methods on *how* to do so. Hence, the current paper also aims at motivating further research by the community in the field of IT-enabled support of planning activities in complex service networks.

Managerial implications cover the development of interest in (semi-)automated planning support and the creation of sensibility for benefits in terms of time and quality resulting from a possible automation. Further, cited references could be used to gain deeper understanding in particular fields of interest.

Limitations of our approach can be found in the focus on one specific modeling framework, i.e. the Ecore metametamodel. However, it is based on the EMOF constraints and thus, it is transferable to other modeling frameworks as well.

With this in mind, future work could cover a transfer to other platforms. Further, a refinement and the development of differing approaches of the automated engineering of process alternatives appears to be an interesting field of research. An evaluation with sample data from real life case studies is an urgent topic for upcoming research.

Acknowledgements. The work presented in this paper was funded by the German Federal Ministry of Education and Research under the project LSEM (BMBF 03IPT504X).

References

1. Gudehus, T., Kotzab, H.: Comprehensive Logistics. Springer, Heidelberg (2012)
2. Arnold, U., Oberländer, J., Schwarzbach, B.: LOGICAL - development of cloud computing platforms and tools for logistics hubs and communities. In: Proceedings of the Federated Conference on Computer Science and Information Systems (FedCSIS 2012), Wroclaw, Poland, 9–12 September 2012, pp. 1083–1090. IEEE (2012)
3. Faber, N., de Koster, R.B.M., van de Velde, S.L.: Linking warehouse complexity to warehouse planning and control structure: an exploratory study of the use of warehouse management information systems. Int. J. Phys. Distrib. Logistics Manag. **32**(5), 381–395 (2002)
4. Stevenson, M., Spring, M.: Flexibility from a supply chain perspective: definition and review. Int. J. Oper. Prod. Manag. **27**(7), 685–713 (2007)
5. Stadtler, H., Fleischmann, B., Grunow, M., Meyr, H., Sèurie, C.: Advanced Planning in Supply Chains: Illustrating the Concepts Using an SAP® APO Case Study. Springer, New York (2011)
6. 4flow AG: 4flow supply chain services (2014). http://www.4flow.de/
7. 4PL Central Station Deutschland GmbH: 4pl central station deutschland - leading provider in europe for fourth party logistics services (2014). http://4plcs.com/
8. Handfield, R., Straube, F., Pfohl, H.C., Wieland, A.: Trends and Strategies in Logistics and Supply Chain Management: Embracing Global Logistics Complexity to Drive Market Advantage. Bundesvereinigung Logistik, Hamburg (2013)
9. Langley, J., Long, M.: 2015 third-party logistics study: the state of logistics outsourcing: the 19th annual study (2015)
10. Esmaeilikia, M., Fahimnia, B., Sarkis, J., Govindan, K., Kumar, A., Mo, J.: Tactical supply chain planning models with inherent flexibility: definition and review. Ann. Oper. Res., 1–21 (2014). doi:10.1007/s10479-014-1544-3
11. Schütz, P., Tomasgard, A.: The impact of flexibility on operational supply chain planning. Int. J. Prod. Econ. **134**(2), 300–311 (2011)
12. Bibhushan, Prakash, A., Wadhwa, B.: Supply chain flexibility: some perceptions. In: Sushil, Stohr, E.A. (eds.) The Flexible Enterprise. Flexible Systems Management, pp. 321–331. Springer, New Delhi (2014)
13. Rushton, A., Croucher, P., Baker, P.: The Handbook of Logistics and Distribution Management: Understanding the Supply Chain. Kogan Page, London (2014)
14. ten Hompel, M., Schmidt, T., Nagel, L.: Materialflusssysteme: Förder- und Lagertechnik, 3rd edn. Springer, Heidelberg (2007)
15. Glöckner, M., Ludwig, A.: Towards a logistics service map: support for logistics service engineering and management. In: Blecker, T., Kersten, W., Ringle, C. (eds.) Pioneering Solutions in Supply Chain Performance Management: Proceedings of the Hamburg International Conference of Logistics (HICL 2013). Reihe: Supply chain, logistics and operations management, vol. 17, pp. 309–324. Eul (2013)
16. Kohlmann, F., Alt, R.: Aligning service maps - a methodological approach from the financial industry. In: Sprague, R.H. (ed.) Proceedings of the 42nd Annual Hawaii International Conference on System Sciences, pp. 1–10. IEEE Computer Society Press (2009)

gloeckner@wifa.uni-leipzig.de

17. Kim, J., Lee, S., Park, Y.: User-centric service map for identifying new service opportunities from potential needs: a case of app store applications. Creativity Innov. Manag. **22**(3), 241–264 (2013)
18. Vaddi, S., Mohanty, H., Shyamasundar, R.: Service maps in XML. In: Potdar, V. (ed.) Proceedings of the CUBE International Information Technology Conference, pp. 635–640. ACM (2012)
19. Kutscher, D., Ott, J.: Service maps for heterogeneous network environments. In: MDM 2006, Japan. IEEE Computer Society (2006)
20. Ryu, M.S., Park, H.S., Shin, S.C.: QoS class mapping over heterogeneous networks using application service map. In: Networking, International Conference on Systems and International Conference on Mobile Communications and Learning Technologies. ICN (2006)
21. Kohlborn, T., Fielt, E., Korthaus, A., Rosemann, M.: Towards a service portfolio management framework. In: ACIS 2009 - Australian Conference on Information Systems, pp. 861–870 (2009)
22. Fleischer, J., Herm, M., Homann, U., Peter, K., Sternemann, K.H.: Business capabilities als basis fähigkeitsorientierte1 konfigurationen. ZWF - Zeitschrift für wirtschaftlichen Fabrikbetrieb **100**(10), 553–557 (2005)
23. VDI-Richtlinie: 3633, blatt 1: Simulation von logistik-, materialfluß- und produktionssystemen (2010)
24. Banks, J.: Handbook of Simulation Principles, Methodology, Advances, Applications, and Practice. Wiley, New York (1998). Co-published by Engineering & Management Press
25. Mutke, S., Klinkmüller, C., Ludwig, A., Franczyk, B.: Towards an integrated simulation approach for planning logistics service systems. In: Daniel, F., Barkaoui, K., Dustdar, S. (eds.) BPM 2011. Lecture Notes in Business Information Processing, vol. 1, pp. 306–317. Springer, Berlin (2012)
26. Ingalls, R.G.: The value of simulation in modeling supply chains. In: Medeiros, D.J., Watson, E.F., Carson, J.S., Manivannan, M. (eds.) Proceedings of the 30th Conference on Winter Simulation, pp. 1371–1376. IEEE Computer Society Press (1998)
27. Cimino, A., Longo, F., Mirabelli, G.: A general simulation framework for supply chain modeling: state of the art and case study. Int. J. Comput. Sci. Issues **7**(2), 1–9 (2010)
28. Longo, F., Mirabelli, G.: An advanced supply chain management tool based on modeling and simulation. Comput. Ind. Eng. **54**(3), 570–588 (2008)
29. Petsch, M., Schorcht, H., Nissen, V., Himmelreich, K.: Ein transformationsmodell zur überführung von prozessmodellen in eine simulationsumgebung. In: Loos, P., Nüttgens, M., Turowski, K., Werth, D. (eds.) Modellierung betrieblicher Informationssysteme - Modellierung zwischen SOA und Compliance Management, pp. 209–219 (2008)
30. Kloos, O., Schorcht, H., Petsch, M., Nissen, V.: Dienstleistungsmodellierung als Grundlage für eine Simulation. In: Thomas, O., Nüttgens, M. (eds.) Dienstleistungsmodellierung 2010, vol. 5, pp. 86–106. Physica-Verlag HD, Heidelberg (2010)
31. Cetinkaya, D.: Model driven development of simulation models: defining and transforming conceptual models into simulation models by using metamodels and model transformation. Ph.D. thesis (2013)
32. Huang, Y.: Automated simulation model generation. Ph.D. thesis (2013)
33. Mutke, S., Augenstein, C., Ludwig, A.: Model-based integrated planning for logistics service contracts. In: Bagheri, E., Gasevic, D., Hatala, M., Motahari Nezhad,

H.R., Reichert, M. (eds.) 17th IEEE International Enterprise Distributed Object Computing Conference, vol. 1, pp. 219–228. IEEE Computer Society (2013)
34. Atkinson, C., Kuhne, T.: Model-driven development: a metamodeling foundation. IEEE Softw. **20**(5), 36–41 (2003)
35. Augenstein, C., Ludwig, A., Franczyk, B.: Integration of service models-preliminary results for consistent logistics service management. In: 2012 Annual SRII Global Conference (SRII), pp. 100–109. IEEE (2012)
36. Augenstein, C., Ludwig, A.: The service meta modeling editor – bottom-up integration of service models. In: vom Brocke, J., Hekkala, R., Ram, S., Rossi, M. (eds.) DESRIST 2013. LNCS, vol. 7939, pp. 386–393. Springer, Heidelberg (2013)
37. Augenstein, C., Ludwig, A.: Interconnected service models - emergence of a comprehensive logistics service model. In: Bagheri, E., Gasevic, D., Halle, S., Hatala, M., Nezhad, H.R.M., Reichert, M. (eds.) 17th IEEE Enterprise Distributed Object Computing Conference Workshops (EDOCW 2013), pp. 239–245. IEEE, Vancouver (2013)
38. Glöckner, M., Ludwig, A., Augenstein, C.: Metamodel of a logistics service map. In: Abramowicz, W., Kokkinaki, A. (eds.) BIS 2014. LNBIP, vol. 176, pp. 185–196. Springer, Heidelberg (2014)
39. ADR: European Agreement Concerning the International Carriage of Dangerous Goods by Road. United Nations, New York (2012). Accessed 15 June 2015
40. Mutke, S., Roth, M., Ludwig, A., Franczyk, B.: Towards real-time data acquisition for simulation of logistics service systems. In: Pacino, D., Voß, S., Jensen, R.M. (eds.) ICCL 2013. LNCS, vol. 8197, pp. 242–256. Springer, Heidelberg (2013)
41. Hoxha, J., Scheuermann, A., Bloehdorn, S.: An approach to formal and semantic representation of logistics services. In: Schill, K., Scholz-Reiter, B., Frommberger, L. (eds.) Workshop on Artificial Intelligence and Logistics (AILog), pp. 73–78 (2010)
42. Romero, J.R., Jan, J.I., Vallecillo, A.: Realizing correspondences in multi-viewpoint specifications. In: IEEE International Enterprise Distributed Object Computing Conference, pp. 163–172. IEEE (2009)
43. Selonen, P., Kettunen, M.: Metamodel-based inference of inter-model correspondence. In: Krikhaar, R., Verhoef, C., Di Lucca, G.A. (eds.) 11th European Conference on Software Maintenance and Reengineering, pp. 71–80. IEEE (2007)
44. Ralyté, J., Rolland, C.: An assembly process model for method engineering. In: Dittrich, K.R., Geppert, A., Norrie, M. (eds.) CAiSE 2001. LNCS, vol. 2068, pp. 267–283. Springer, Heidelberg (2001)
45. Castano, S., De Antonellis, V.: A constructive approach to reuse of conceptual components. In: Proceedings of the Advances in Software Reuse (1993)
46. Jilani, L.L., Mili, R., Mili, A.: Approximate component retrieval: an academic exercise or a practical concern. In: Proceedings of the 8th Workshop on Istitutionalising Software Reuse, Columbus, Ohio (1997)
47. Klarmann, A., Franczyk, B., Mutke, S., Roth, M., Ludwig, A.: Continuous quality improvement in logistics service provisioning. In: Abramowicz, W., Kokkinaki, A. (eds.) BIS 2014. LNBIP, vol. 176, pp. 253–264. Springer, Heidelberg (2014)

gloeckner@wifa.uni-leipzig.de

8.2 Executive Summary

The paper demonstrates the *application* of the service map concept in the context of tactical planning of logistics services. A method for (semi-)automated engineering and evaluation of different alternatives of composite logistics services is engineered. Via a metamodeling approach [Atkinson and Kühne, 2003], two basic components are brought together, i.e. service map for engineering of new service alternatives and a simulation approach for the evaluation of those alternatives afterwards. Method engineering [Ralyté and Rolland, 2001; Castano and Antonellis, 1993] is used to design a (semi-)automated comprehensive approach. The paper answers no particular research question of the thesis but gives a first application example of one of the core components.

The presented method fills the lack in concreteness of planning methods for tactical logistics process planning in literature. The systematic creation of distinct process alternatives in particular is not part of existing planning methods, neither is their (semi-)automated evaluation. The approach presented in this paper is based on a combined catalog and construction system (for engineering) and a generic simulation approach (for evaluation) that are able to handle the variety of service descriptions in logistics. The basic artifacts are presented and connected by a model-driven approach afterwards. Finally, a method is developed to facilitate a semi-automated engineering and evaluation of process alternatives. The method is presented in Figure 8.1

In terms of contribution type level (see Table 1.2) and the kind of knowledge contribution (see Table 1.9), the artifact of the paper can be characterized as follows: The developed method is based on existing artifacts from the context of service engineering and management, and process simulation. The solution helps to facilitate (semi-)automated tactical planning in logistics and thus the artifact embodies an improvement. The engineered method can be used to solve a range of problems. Hence, it is located on the second contribution type level.

This paper presents an example of application of the service map concept. The results are not further used in the context of other papers of the thesis.

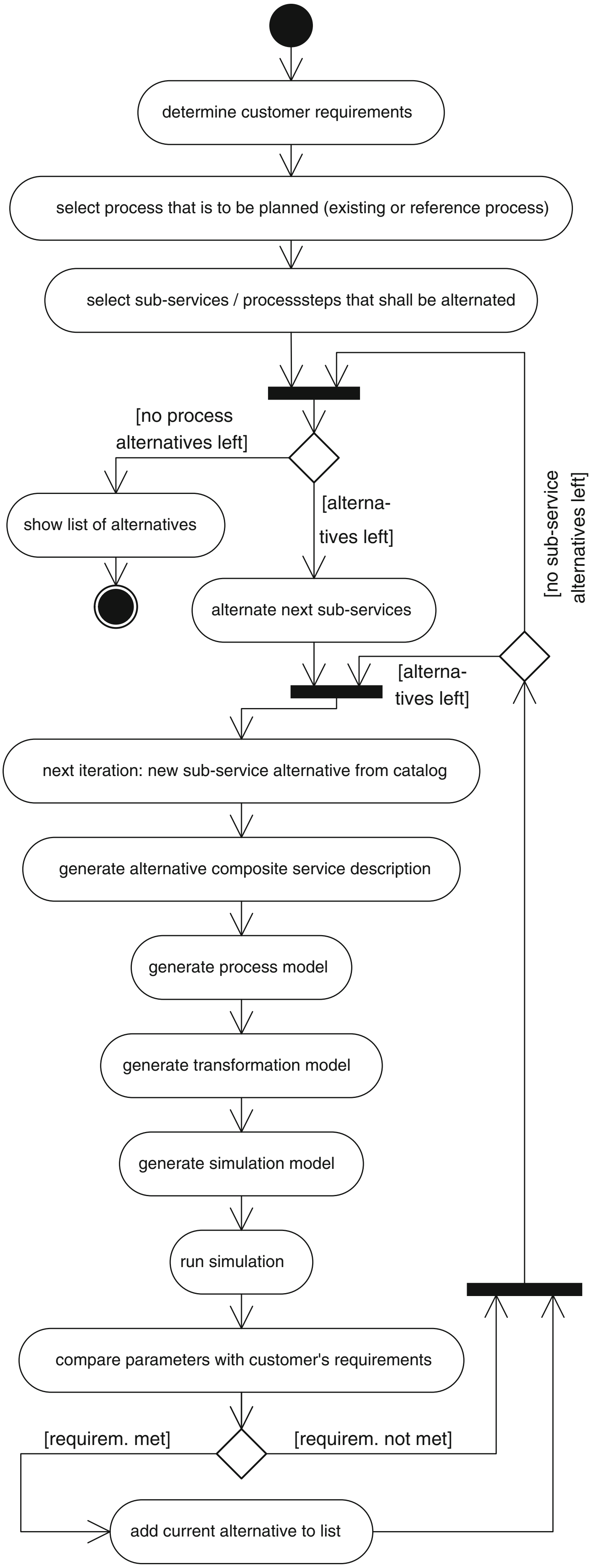

Figure 8.1: Activity diagram of the resulting method.

9 Consolidation and Research Roadmap

Glöckner, Michael; Ludwig, André: Towards the Conception of Cloud Logistics - Engineering and Management of Modular Cloud Logistics Services in the Context of Flexible Future Supply Chains. (publication ready) [Glöckner and Ludwig, 2019].

9.1 "Towards the Conception of Cloud Logistics - Engineering and Management of Modular Cloud Logistics Services in the Context of Flexible Future Supply Chains"

Table 9.1: Meta data of the publication (Consolidation and Research Roadmap).

DOI	tbd
URL	tbd
Type	Journal Paper
Publication in	tbd
Editor	tbd
Series Title	-
ISSN / ISBN	tbd
Publisher	tbd
Place of Publication	-
Ranking	CORE: - VHB: - h-index: -

International Journal of Physical Distribution & Logistics Management

emerald PUBLISHING

International Journal of Physical Distribution & Logistics Management

Towards the Conception of Cloud Logistics

Journal:	*International Journal of Physical Distribution & Logistics Management*
Manuscript ID	Draft
Manuscript Type:	Research Paper
Keywords:	Cloud Logistics, Service Blueprint, Service Map, Ontology, Design Science Research

SCHOLARONE™ Manuscripts

Towards the Conception of Cloud Logistics

Engineering and Management of Modular Cloud Logistics Services in the Context of Flexible Future Supply Chains

Structured Abstract

Purpose – The paper takes a first step towards a digitalized logistics industry as an essential part of SCM 4.0. Cloud principles are adopted to logistics and generic basic modules of logistics services are created. The digital interconnection of logistics service providers as well as the basis for connecting sensors and analytics to logistics services is facilitated. A digitalized logistics enables digital business strategies in SCM and thus, digital interaction and embedding in digitalized manufacturing and production industry is facilitated.

Design/methodology/approach – A design science approach is used that focuses on the creation of IT artifacts. Based on the framework of design oriented information systems research several methods are involved to analyze, design, and evaluate the artifacts.

Findings – The paper presents a comprehensive conceptual elaboration of the cloud logistics paradigm: a definition of 'cloud logistics' and foundational artifacts for the engineering of generic modular cloud logistics services as well as for the management of those services. Finally, a prototypical implementation is presented.

Research limitations/implications – Next to the development of a comprehensive conceptual framework of cloud logistics, the integration of two existing layer streams, i.e. computing and resource centric, into one framework is an important achievement. An initial set of artifacts has been developed, creating a starting point for future research on cloud logistics and digitalized supply chains.

Practical implications – Practitioners get an overview of the potential and possibilities of the cloud logistics paradigm.

Originality/Value – The paper contains a first comprehensive conceptual framework as well as a first scientific definition of cloud logistics.

Keywords: Cloud Logistics, Service Blueprint, Service Map, Ontology, Design Science Research

Article Type: Research Paper

Introduction

The digital shift in the industry, known as industry 4.0 or smart manufacturing, influences all aspects such as design, manufacturing and delivery of products [1] as well as whole business models towards a digital business strategy [2] by combined digital technology and operation capabilities in a well-integrated way in order to increase revenues by sophisticated customer experience [3]. This shift towards digitalization within particular companies and industries as well as within their connections also implies impact and changes to the connecting supply chain management and the logistics operation in those networks [4], which is – in relation to the term industry 4.0 – defined as Supply Chain Management 4.0 (SCM 4.0) [5] that particularly focuses on the digital interconnection of the several supply chain parties and logistics service providers. Hence, one of the resulting essential challenges is the digital interconnection of the logistics service providers (LSP) maintaining the operational physical connection of the supply chain members. As only little research is done on the impacts of industry 4.0 on supply chain aspects [6] and further, [7] encourage SCM researchers to tackle underrepresented research topics a rather young research approach in the field of digitalized logistics is introduced: one promising approach of a digitalized interconnection of LSP is the paradigm of 'cloud logistics' [8] that adopts basic cloud computing principles, such as resource virtualization and encapsulation in reusable modular services, to the logistics industry in order to facilitate planning aspects and thus to digitalize physical logistics resources and make them compatible and easy connectable. In the following the parallels between cloud computing and logistics are presented in order to give an understanding of the basic principles of cloud logistics.

Cloud computing (CC) describes a paradigm for the provision and usage of computing resources over a network, summarizing almost any solution that builds on outsourced hosting and provisioning of hardware and software resources. The technologies cloud computing is based on (e.g. distributed software systems, virtualization of resources and service-oriented architecture) have existed before the term 'cloud computing' had come into existence. However, the paradigm of cloud computing provides a stable set of principles, definitions, and functionality that made it a disruptive technology and game changer in the computing industry [9, 10]. In particular, the notion of services as a basic unit of resource abstraction has gained momentum within cloud computing. Services are self-contained entities that encapsulate functionality and can be invoked on demand by standard interfaces [11]. They are the building blocks for designing composite solutions. The widely accepted NIST definition [12] of cloud computing summarizes in its cloud model, that three distinct service models can be abstracted: software, platform and infrastructure as a service (SaaS, PaaS and IaaS). Services can also be provided in four service deployment models: private, hosted private, community and public. They contain essential characteristics such as on-demand access via standardized network interfaces and instead of a fixed allocation of resources, cloud services can be pooled dynamically, leading to rapid elasticity and economies of scale.

Cloud computing has received high acceptance in the computing industry, changing the roles of computing resources on multiple levels. Due to easy resource virtualization, infrastructure services have become commodities with a low level of differentiation opportunities leading to high competition and low customer loyalty [13]. Storage and computing can even be used free of charge, i.e. Dropbox[1] or Amazon Elastic Cloud[2]. Today, software services can be highly customized and integrated towards customer demands, offering new ways for differentiation and adoption. With broad access over standard network interfaces, new customer segments can be entered, i.e. for specialized applications. This has led to some major organizational changes in corporations. IT departments no longer manage their own computing centers. Instead they are responsible for selecting, contracting, monitoring externally provided

[1] https://www.dropbox.com
[2] https://aws.amazon.com

services, and ensuring that respective service providers meet required governance standards and service level agreements.

Not only has cloud computing changed the computing industry, but its design principles have also initiated the transformation of other industries, such as logistics. Logistics [14] is defined as the function of planning, implementing, and controlling the efficient and effective flow of goods and information from point of origin to point of consumption. Its objective is the transformation of goods in several dimensions, e.g. space, time, and quality according to customers' demands. Driven by globalization, customer individualization and modern production concepts, such as just-in-time delivery and synchro-modality, logistics has become one of the largest service sectors in many countries over the last several years [15]. Subsequently, it has experienced tremendous change (e.g. by the digitalization of manufacturing industry [1, 4]); thereby a number of similarities can be recognized between computing and logistics services.

Logistics services are offered in various levels of abstraction in different service models. Basic services, such as transportation or warehousing – so-called second party logistics services (2PL) – comprise infrastructural services. More advanced services – so-called third party logistics services – build up on those basic services, combine them with value-added services (such as sequencing, labeling or customs), and are highly geared towards customer demands. Succeeding those are the so-called fourth party logistics services, which focus on planning and coordination activities of virtualized logistics services without asset binding. Typically, logistics resources that are actually used for accomplishing a certain task are invisible, e.g. which truck transports which freight on which transport.

From an organizational and deployment point, further parallels between logistics and cloud computing can be observed. In the past, most manufacturing companies operated an on premise logistics department utilizing their own systems and assets. Recently, more operational and repetitive services in logistics have been outsourced [15] and logistics services are being offered on customer premises based on tenders, i.e. logistics service providers work within the manufacturer's factory (private use), on external premises for exclusive use by a customer (hosted private use), or externally for usage by a limited network (community use) or the general public (public use). Consequentially, modern corporate logistics departments end up fulfilling coordinative functions; managing tenders, service providers and service levels instead of owned assets. Furthermore, cloud and logistics services follow a similar provisioning model, as illustrated in Figure 1, facing similar requirements. They are asked to support rapid provisioning, flexible pricing, elastic scaling and resilience. Additionally, in order to remain competitive, they need to provide opportunities for collaboration and integration in the division of labor while simultaneously focusing on core competencies [15] and advanced digitization [16, 17].

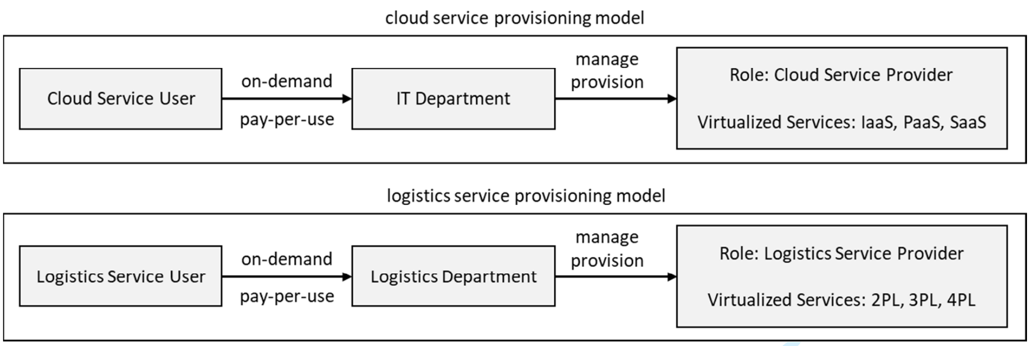

Figure 1: Cloud and logistics service provisioning models.

However, contrary to cloud computing, logistics currently lacks the fundamental design principles to organize systems and suffers from poor communication which leads to the failure of logistics outsourcing partnerships [18]. Those aspects also explain why more complex and sophisticated logistics services that are more strategic, IT-intensive, and/or customer-facing are less likely to be outsourced [15] and thus, why logistics as an important part of SCM needs improvement in digitalization. Logistics services need to be modelled more similarly to cloud services as access and monitoring interfaces are currently not as stable. Further, resource virtualization and scalability cannot be utilized to their full extent, as service composition doesn't contain stable service structure and categorization to build upon. Short: standardized modules as a basic platform to connect sensors and analytics, as basic parts of digitalization, are missing. Therefore, we propose to integrate the principles of cloud computing with the characteristics of the logistics service sector. Thus, the central research question is reached:

"How should a logistics service system be designed as to adopt cloud principles?"

To answer this, we begin by structuring the problem domain and describing the theoretical background. Next, we present our conceptual model of cloud logistics (CL) with artifacts: a cloud logistics service blueprint that embodies the essential flows and transformations of the logistics domain by means of a logistics service, and a logistics service map that structures and categorizes logistics services based on an according metamodel. Finally, we evaluate the developed conceptual model based on a use case of an international operating logistics company.

Methodology

In order to answer the presented question, a design science approach of Hevner et al. [19, 20] is used. Relevance is shown by motivating and evaluating the developed artifacts with practical examples. Rigor is granted by applying approved frameworks and methods from the information systems (IS) field. Figure 2 provides the methodological outline and structure of the paper. The leading framework used is the design oriented information systems research of Österle et al. [21] with the phases of problem analysis, artifact design, evaluation, and diffusion. The problem is decomposed into service landscape and service map in order to develop separate artifacts for distinct parts of the problem. The analysis phase uses the state of the art and the existing literature stream in order to define and structure the problem. During subsequent phases, artifact design heuristics are incorporated to develop solution components that meet the requirements from the analysis.

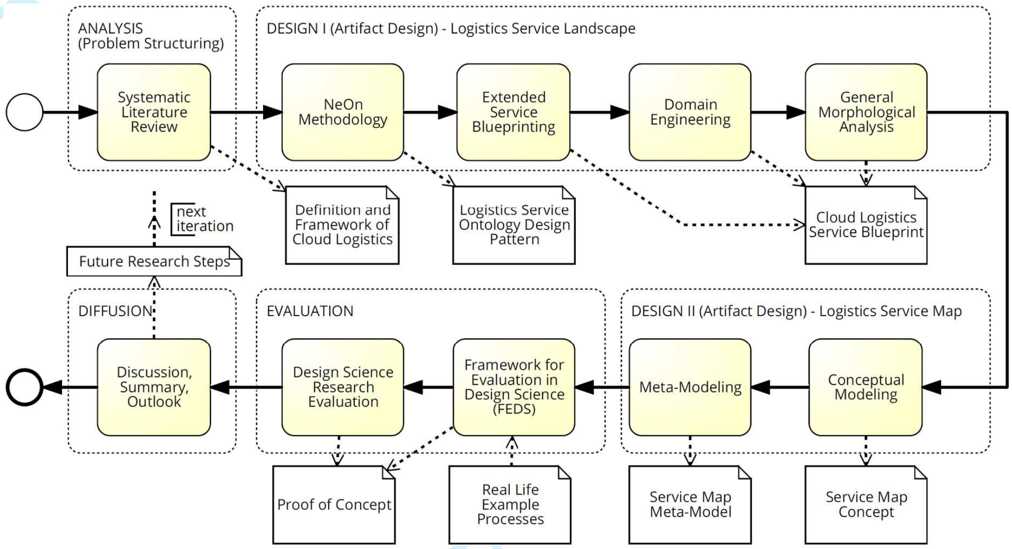

Figure 2: Methodological Framework with integrated Methods and the resulting Structure of the Research.

Analysis focuses on the outlining of the problem space [22] with givens, goals and operations [23]. Existing CL literature is used to conceptualize the topic and to carve out specific research gaps and requirements using a systematic literature review [24]. Problem-structuring heuristics [25, 26] are taken into account in order to give a working definition of CL and split the formulated problem into two sub problems.

The *design* phase solves the two sub problems with regards to the artifact design heuristics of analogical design [27], ideation, prototyping, and modeling [28, 29]. The first block focuses on the conceptualization of the logistics service landscape by developing the basic cloud logistics service blueprints (using the methods of extended service blueprinting [30], domain engineering [31], and general morphological analysis [32]) as well as the service granularity framework with the help of another systematic literature review [24]. In addition, a map is developed in order to navigate in the landscape of CL with the help of conceptual modeling [28, 29] and metamodeling [33].

For *evaluation* purposes, the recommendations of Briggs et al. [34] are followed, taking real life processes into account and formulating a prototype. The leading method of evaluation is Venable et al.'s framework for evaluation in design science research (FEDS) [35] ,along with a few aspects of Peffers et al.'s [36] methods.

Diffusion has been accomplished by publications on some of the presented artifacts (see [37–39]). Further, it is supported by the integration of the results into the existing state of the art, the discussion of implications for researchers and practitioners, and in the discussion of future research issues of CL, as well.

Stream of Research - Outline

The cloud principles – from computing to logistics

As indicated in the introduction, cloud and logistics services have similar characteristics and share similar visions. Despite the similarities, logistics lacks the definitions and models that cloud computing has already achieved. Therefore, we propose translating cloud characteristics to logistics services. The following text will compare logistics against cloud characteristics in order to provide a stable theoretical background for our conceptual model. Due to the large number of existing definitions, we utilized the cloud characteristics collected by Vaquero to compare the most common approaches to defining cloud computing [40]. Vaquero's characteristics are: user access, resource heterogeneity, virtualization and sharing, standardization, scalability and resource optimization, payment model, and service level agreements (SLA). Table 1 summarizes how these characteristics apply to cloud and logistics services respectively.

As a minimum, the characteristics of scalability, the pay-per-use utility model and virtualization must be taken into account when defining a model that translates cloud characteristics [40] to logistics. In order to further theorize our approach, we have adopted the term Cloud Logistics (CL) [44] as an integrated concept that implements cloud principles for logistics service systems design. In order to get an overview of the state of the art, a systematic literature review [24] has been conducted.

Table 1: Comparison and translation of principles from cloud computing services to logistics services.

Characteristics	Cloud Services	Logistics Services
User access	Easy and transparent access for end users due to standardized interfaces and self-configuration mechanisms.	Access is mainly a manual task. Easier self-access and reconfiguration can be achieved by adding stable interface definitions as outlined below.
Resource heterogeneity, virtualization and sharing	Interfaces hide the heterogeneity of hardware resources (such as CPU, storage) and software resources (such as operating or application systems). This virtualization enables resource sharing by overcoming the isolation of dedicated resources.	The actual operation of logistics services (such as transportation or transport management) is regularly outsourced to additional providers. Hence, the 'hardware' (such as trucks) and the 'software' (such as tools and knowledge) of logistics can also be hidden behind certain kinds of interface. Their virtualization holds a lot of potential for more flexible usage and sharing of resources. Especially, homogeneous assets, like trucks or management systems of which are predestined for shared usage.
Standardization	To support on-demand usage, cloud services are largely characterized by standardization in accessing resources, reaching interoperability, and enabling scalability.	Logistics is a domain that has experienced dramatic changes due to the introduction of standardization, i.e. sea ship containers, EDI standards etc. However a conceptual standardization of logistics services lags behind in terms of usability, e.g. SCOR being too generic and not adaptable nor practical [41].
Scalability and resource optimization	Cloud services provide scalability based on virtualized hardware resources and dynamic reconfiguration [42]. Available computing resources limit scalability. Resource optimization follows dedicated rules that determine how resources are optimally shared between users.	As daily practice, scalability in logistics services is achieved by adding additional logistics resources (e.g. further trucks). However, this can only be achieved by introducing standard interfaces that allow automated scaling by contracting logistics operators on demand. Similar to cloud services, scalability is limited in reach by available resources and physical distance. Optimization of virtualized resources is controlled by rules that can be set to prioritizing certain customers or maximizing utilization, i.e. of freight spaces.
Payment model	Cloud services are usually billed by pay-per-use model. This can also be related to different SLA.	Logistics can be billed by pay-per-use as well. This is based on distances, number of entities, or duration.
Service Level Agreements	Quality of services is guaranteed as defined in SLA. This forms an inherent feature of many cloud service offerings, e.g. Amazon. Customization is possible, but obviously varies [43].	Defining quality is a main aspect of logistics services. However, currently these qualities are outlined in arbitrary formats and bilateral contracts. Formalized SLA for logistics services would dramatically extend rapid enactment and resource allocation.

State of the art of cloud logistics

Methodological remarks concern modern technology and its influences on the conduction of research by the vast amount of information that's available within mere seconds of a database query. With so much information, the accomplishment of a 'comprehensive' literature analysis and synthesis stretches human perception beyond its limits. Therefore, in order to focus on a reasonable amount of high quality publications, the strategy suggested by vom Brocke et al. was used, which first focuses on the most seminal publications within a field and then uses those publications in a backwards search to build a body of literature [24].

When searching the keywords ‘cloud logistics’ via google scholar, approximately 27.500 articles came up. Hence, the search criterion was narrowed down to publications with the exact term in the title, as to find papers with a deep focus on the topic. The analysis comprised seminal work that recognized CL as a disruptive paradigm and not just as a usage of CC in the logistics domain. Thirteen papers make up the seminal work in the field of CL and are complemented by an additional two papers, found through forward and backward searches as shown in Table 2. Consequently, it can be confirmed that CL is still a research topic in its infancy and requires further attention as discussed by Delfmann et al. [44]

Table 2: Results of database search for papers with 'cloud logistics' in title.

database	result	included	2010	2011	2012	2013	2014	2015	2016
google scholar www.scholar.google.com	59	9	1	-	-	-	5	2	1
Springerlink link.springer.com	19	2	-	-	1	1	-	-	-
Science Direct www.sciencedirect.com	6	1	-	-	-	1	-	-	-
IEEE Xplore Ieeexplore.ieee.org	6	3	-	-	2	-	1	1	-
Web of Science Apps.webofknowledge.com	1	0	-	-	-	-	-	-	-
Emerald Insight www.emeraldinsight.com	0	0	-	-	-	-	-	-	-
ACM dl.acm.org	0	0	-	-	-	-	-	-	-
Forward and Backward	2	2	1	1	-	-	-	-	-
Total	93	15	2	1	3	2	6	3	1

The resulting insights on conceptualization are organized into 4 categories:

(1) Concerning a *Definition of CL*, most publications refer to either Holtkamp et al. [45] or Li et al. [46] (of whom also refers to Holtkamp et al.). Interestingly, Holtkamp et al. do not give a proper definition of CL, but describe the strong influence of cloud principles on the logistics

domain. Therefore, a proper definition is missing. Common characteristics involve the virtualization of physical resources to logical (virtual) resources and their encapsulation within distinct logistics services.

(2) *Layers of CL* are of different numbers (3-6) and characteristics (IaaS/PaaS/SaaS [41, 45, 47, 48] and/or physical/virtual/service [41, 46, 49–53]).

(3) *Virtualization* is realized by approaches, which are semantic-oriented [45, 46, 48, 52], object-oriented [51, 52] or categorization-oriented [41, 46, 50, 52].

(4) *Encapsulation* builds upon already described service models [41, 47, 54], offers first ideas for interfaces [41, 45, 47, 51], and XML-based descriptions [41, 45–47, 51]. Even the idea of generic building blocks is introduced: publications [45, 51] focus on building blocks of the entities within logistics systems but not of the services, and [47] describes cloud blueprints.

After aggregating those categories it is clear that the knowledge gained needs to be synthesized and further fostered with insights from literature in order to contribute to current state of the art on CL, and to make the state of the art concrete and valuable to researchers and practitioners.

Definition of Cloud Logistics

Based off of the first insight, a working definition of cloud logistics is developed utilizing the cloud computing definition of NIST [38]:

Cloud Logistics is a model, based on and inspired by the paradigm of cloud computing, for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable and virtualized logistics resources (e.g. means of transportation, warehouses, domain-specific knowledge, logistics applications) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

This cloud model is composed of the five essential characteristics of cloud computing (on-demand self-service, broad network access, resource pooling, rapid elasticity, and measured service), but is adjusted respective to the more physical character of logistics. This adjustment comprises: a location dependency of services, up-to-date knowledge of current location, and a lower elasticity due to time consumption for allocation of physical resources.

The domain-specific layer, Logistics-as-a-Service (LaaS), is added to the CC service models. The consumer gains capabilities in provisioning transport, storage, handling, knowledge and other fundamental logistics resources where the consumer is able to ship, convey and transform both physical and non-physical, i.e. informational, logistics entities. The logistics resources are purchasable through interfaces combining GUI and/or API. The consumer does not manage or control the underlying logistics infrastructure, but has control over the source and sink location, the transformation of the entities shipped, as well as control over the configuration settings for the transformation-enabling environment.

The deployment of LaaS, results in different business models of Logistics Service Providers (LSP): public cloud (for networks), private cloud (for big LSP with a comprehensive service portfolio), and hybrid (for participation of big LSP in networks or as the basis of the business model for big LSP to become a Lead Logistics Provider (LLP)).

The Layers of CL

According to the previous analysis, the layers are twofold. Subsequently, a *Framework of Cloud Logistics* is derived that combines both perspectives. It is mainly inspired by the Supply Chain-as-a-Service (SCaaS) framework of [41] that is modified and extended, as seen in Figure 3.

The virtualization of computing resources is adapted to (mostly physical) logistics resources. By encapsulating them, logistics services gain shape and can then can be freely combined. The foundation for such a flexible modular collaboration is the building blocks concept, as known as Logistics-as-a-Service (LaaS) [55] (which are also inspired by the BPaaS approach [56, 57]). LaaS describes the essential flows and transformations of the logistics domain in order to virtualize resources from different providers to compatible modular cloud logistics services. The objective is always the transformation or manipulation of certain objects. Heeding [54], an integrated view is supported by following the approach of service blueprinting for engineering cloud logistics as a product service system.

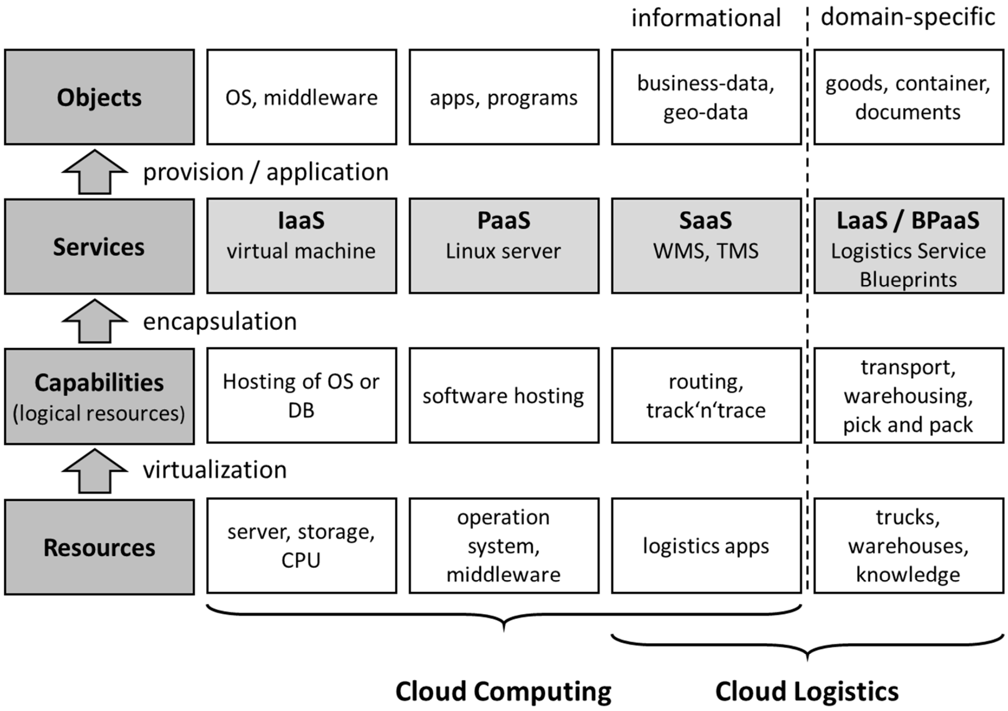

Figure 3: Framework of Cloud Logistics, adapted and extended from Leukel and Scheuermann [55].

Virtualization and Encapsulation – Research Questions

After defining CL and integrating it into the existing framework of CC with the extension of a domain-specific layer, the core principles of resource virtualization and their encapsulation within services, i.e. LaaS, are challenging tasks. As previously stated, there are multiple general approaches, but no comprehensive and complete method regarding virtualization of resources and their encapsulation within reusable modules. It lacks an easily connectable 'Lego Brick' system of logistics services and a useful practice-oriented approach for their management. Promising methodologies in terms of reusability and inter-connectability are the semantic-driven virtualizations [45, 46] and the encapsulation in XML-based cloud blueprints [47]. Now, these approaches are to be refined, connected, and transformed to the logistics domain.

Researchers haven't investigated the management of CL services either. The application of the 'Lego Brick' system must be based on standardized building blocks that integrate computer and logistics resources. The results are a twofold challenge for engineering and management of CL: (1) The description of the 'landscape' of CL service in terms of semantic-based cloud logistics service blueprints (i.e. the engineering) must be developed. (2) The description of the 'map' of such blueprints that facilitate retrieval and composition (i.e. the management) must be generated. Based on these prerequisites, several research questions arise:

1. What are suitable ways to semantically virtualize logistics services?
2. What are suitable modules that encapsulate cloud logistics service blueprints?
3. What is a suitable concept for the retrieval and composition of cloud logistics service blueprints?

Conceptual Model

In this section, the artifacts from the conceptual modeling of CL will be presented. The first part focuses on the research regarding the semantic description of logistics services in order to facilitate virtualization, on-demand access, and connections of logistics resources from different LSP creating easy access, scalability, and inter-connectability. The resulting research will be integrated into the Lego Bricks of Cloud Logistics concept inspired by cloud blueprinting, generating easy user access. The second portion involves the development of a conceptual model for the management of Cloud Logistics Service Blueprints in terms of a logistics service map and introduces its metamodel.

The Service Landscape - Engineering

This sub-section will focus on the virtualization of logistics resources in terms of a semantic description and their encapsulation within a conceptual service description model.

Ontology Design Pattern for Logistics Services

The semantic description of logistics services offers the possibility of integrating data and knowledge from different LSP in order to enable CL. An important advantage of semantic web techniques for knowledge representation and reasoning, is the bridging of the gap between concepts, syntax and vocabulary [58] of different LSP [59]. Thus, logistics is turned into an open and collaborative space. Different LSP can be integrated faster and more flexibly [59], which facilitates planning and re-scheduling activities in cases of uncertainties [60]. Further, implicit knowledge can be discovered by reasoning [58]. Ontologies are an appropriate way of managing and representing knowledge, making it accessible and understandable to both human beings and machines. They enable the formal naming and definition of objects, properties, and their interrelations [58, 61]. The approach of the Ontology Design Pattern (ODP) [62] is used to facilitate ontology engineering by creating reusable artifacts with varying purposes [63], e.g. content ODP, reengineering ODP, logical ODP, etc.[3] The advantage of ODP is [62] that Ontology engineers can then draw on those patterns to reduce time and mistakes during the ontology creation process. Additionally, design and communication is easier for both knowledge engineers and domain experts. Hence, ontology integration is facilitated. ODP has proved [64] to be perceived as useful, improving the ontology quality, increasing the task coverage, enhancing usability, and in avoiding common modelling mistakes.

ODP forms a trunk ontology of logical structure or domain-specific knowledge, which is to be extended and further filled with classes, objects, properties and individuals according to the

[3] http://ontologydesignpatterns.org

specific problem and context. In order to model domain specific concepts, the type of 'content ODP'(CP) is appropriate [65].

The semantic web community has not paid much attention to the logistics domain yet. Even though the review of Scheuermann and Leukel [66] reveals there are existing ontologies in literature dealing with logistics aspects, none of them fulfills the requirements of linked data of the W3C-standard[4] as there are no URI (unified resource identifier) nor machine readable XML files. The existing ontologies are customized and cannot be re-used due to proprietary formats, thus, they are neither standardized nor inter-linkable. The existing conceptual overlaps from frequently used concepts in the few found ontologies can be seen as important domain-specific aspects that are to be integrated into a CP of logistics services.

Ontology engineering methods can be applied to the development of ODP as they are a kind of blank ontology. The leading approach used is the NeOn methodology [67] combined with the approach of a CP definition [65]: Begin by posing competency questions in order to specify requirements, and then use the requirements to analyze, assess and select concepts. Those concepts can be found in existing ODP, existing logistics ontologies concepts, and non-ontological concepts of the logistics domain. Afterwards, they are merged and the essential aspects of logistics services are extracted in order to develop the final ODP for logistics services. The ODP is presented in terms of a schematic view, conceptualization, and formalization.

Related ODP that are re-used are the following: time interval CP[5] [68], material transformation CP[6] [69], and TransportPattern[7] [70]. *Related ontologies* of logistics and supply chain management are taken from the review of [66] that discusses 16 ontologies. Through further search activities, another 12 papers were discovered presenting concepts on

[4] https://www.w3.org/standards/semanticweb/data
[5] http://www.ontologydesignpatterns.org/cp/owl/timeinterval.owl
[6] http://www.ontologydesignpatterns.org/wiki/Submissions:Material Transformation
[7] https://wiki.auckland.ac.nz/download/attachments/52016791/TransportPattern.owl

the domain of focus. The extracted essential concepts for an ODP on logistics services are presented in the following:

- A distinction into *physical resources* and *informational resources* can be found in [46, 71–74]. Informational resources are detailed into documents and information systems. Physical resources, such as transportation and manpower [75, 76], are abstracted into capabilities, and functional and unfunctional [sic] parameters [52].
- Logistics objects that can be contained by other logistics objects are described [45, 51, 77, 78]. They are seen as passive entities (goods or passive resources such as packaging or containers) that are transformed by active entities (active resources such as trucks or information systems). Another paper introduces the concept of an agent that is acting on an entity with the help of distinct equipment [79]. From this point of view, a distinction between *active resources* (acting agents) and *passive resources* (used equipment) can be derived.
- Performance measures and logistics *KPI* are outlined in the publications of [72, 75, 77, 78, 80].
- *Location* as a crucial aspect of logistics is emphasized by [74, 77, 79].
- *Time* plays a crucial role in all logistics activities [74, 81].
- Different Roles and *Stakeholders* are described in [74, 75, 77, 80].
- *Objectives of logistics* are refined into social, environmental and economic [80].
- *Input* and *output* of logistics activities are outlined and partly refined into resources, materials, and information [82].
- *Policies* are integrated by [81].
- Distinct *goods* are described in the approach of [83].

Additionally, *non-ontological concepts*, i.e. general domain-independent service models and essential domain-specific logistics characteristics, are integrated into the logistics service ODP. Hoxha et al. [75] outline a basic model of a logistics service with inputs and outputs as well as preconditions and results (i.e. conditions, constraints, effects). General service definitions, such as [84, 85], describe the application of knowledge and skills, and the usage of resources within activities or processes with the aim of generating benefits for another entity or for the entity itself. Also, the immediate interaction with the receiving entity in order to solve an existing problem is outlined. Shortly, service is briefly defined as the usage of resources for the benefit of an entity. Subsequently, the following aspects are conceptualized for the logistics domain: resources, benefits (transformation of conditions), and interactions (input and output).

Furthermore, aspects of the logistics domain are taken into account as essential concepts of a logistics service ODP. Basic flows of logistics comprise *informational flow* and *physical flow* [14] as well as the *flow of control* [70] in terms of the CL paradigm. Logistics experts frequently describe logistics using the *7-rights* [86] that reflect the basic objectives of successful logistics activities, which are to deliver: the right product, with the right information, to the right location, in the right time, in the right quality, in the right quantity, for the right price. As logistics is responsible to deliver those aspects in the 'right' way, it must possess the ability to control those aspects. The manipulation of those aspects implies their *transformation* during the provisioning of logistics service concerning the customers' demands and requirements. *Legal constraints* are also important to the logistics domain, e.g. permission to handle dangerous goods [87], or the legal regulations regarding the allowed period of driving and rest during road transport [88]. Subsequent, the presented concepts are merged into one design pattern.

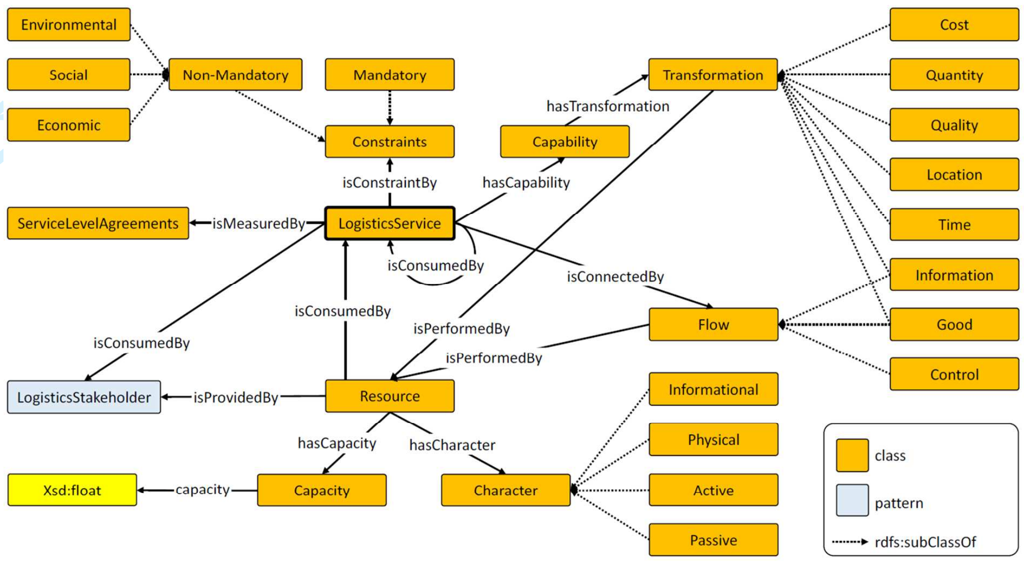

Figure 4: Schematic view of the ontology design pattern for logistics services.

The developed ODP, presented in Figure 4, can be found online[8] in a formalized way[9] in OWL 2 Web Ontology Language[10] [89]. The central object is the *LogisticsService*, which can be consumed by itself in terms of incorporation of sub-logistics services. *Resources* with a distinct *Character* and *Capacity* are consumed during service provision and enable a certain *Flow* and *Transformation*. LogisticsServices are measured by *ServiceLevelAgreements* and constrained by *Mandatory* (e.g. legal regulations) and *Non-Mandatory Constraints*. Resources are distinguished in two ways: on the one hand, they can be described as *physical* (e.g. staff, forklifts, trucks, and containers) or *informational* (e.g. warehouse management system (WMS), pick list). On the other, resources can be classified as *active* and able to perform certain transformations (e.g. forklift, WMS), or as *passive* and used to carry goods or information (e.g. container, pick list). Several axioms are presented in description logic [90] in order to enable better reasoning:

(1) Flow $\sqsubseteq$ isPerformedBy.Resource $\sqcap$ hasCharacter.Active

(2) LogisticsService $\sqsubseteq$ $\forall$isConnectedBy.Information $\sqcap$ $\forall$isConnectedBy.Control

[8] https://github.com/Michael-Gloeckner/LoSe_ODP
[9] https://github.com/Michael-Gloeckner/LoSe_ODP/blob/master/LoSe_ODP.owl
[10] https://www.w3.org/TR/owl2-overview/

(3) Information $\sqcup$ Control $\sqsubseteq$ isPerformedBy.Resource $\sqcap$ hasCharacter.Informational

(4) Good $\sqsubseteq$ isPerformedBy.Resource $\sqcap$ hasCharacter.Physical

(5) Transformation $\sqsubseteq$ isPerformedBy.Resource $\sqcap$ hasCharacter.Active

(6) Capability $\sqsubseteq \geqslant 1$ hasTransformation.Transformation

(7) LogisticsService $\sqsubseteq \geqslant 1$ hasCapability.Capability

(8) Informational $\equiv \neg$Physical

(9) Active $\equiv \neg$Passive

With resources, *LogisticsServices* perform *transformations*. *Flows* connect them with each other and require *active* resources (see axiom 1). *Information* and *Control* are obligatory (see axiom 2). Both obligatory flows are performed by *informational* resources (see axiom 3). The flow of goods is performed by *physical* resources (see axiom 4). *Transformations* are performed by *active* resources (see axiom 5). The capability of a *LogisticsService* always consists of at least one *transformation* (see axiom 6). One *LogisticsService* is always capable of at least one *capability* (see axiom 7). Through transitivity, the conclusion that every *LogisticsService* has to incorporate at least 1 *active* resource can be drawn (axioms 5 - 7). *Resources* with an *active* character (such as trucks, fork lifts, conveyor and sorting machines) are able to move goods actively or transform *information* actively (such as Transport Management Systems). *Resources* with a *passive* character are entities that contain *goods* (such as packaging or containers) or *information* (such as documents, pick lists, contracts). *Constraints* that are *Mandatory* (e.g. laws, permissions, regulations) or of other objectives (e.g. ecological or social objectives, such as CO_2-reduced) influence the *LogisticsServices*. The *character* of a *resource* can be either *informational* or *physical* (see axiom 8) or either *active* or *passive* (see axiom 9).

In summary, with the help of the ODP, the resources underlying the logistics services can be virtualized. With simple 'sameAs' properties, connections can be established, resources from different LSP virtualized and the semantic gap bridged. This semantic core is wrapped into a conceptual model of generic blueprints, constructing a more user-friendly and understandable building block approach of logistics services, even for non-skilled LSP.

Engineering Method for Cloud Logistics Service Blueprints

With the help of several methods, the generic concept of cloud logistics service blueprints (CLSB) is developed. This comprises: the *extended service blueprinting* [30] for the general incorporation of human- and machine based service aspects; *domain engineering* [31] in order to find common and varying domain-specific points for engineering; and *general morphological analysis* [32] to structure the multidimensional problem complex and identify the possible spectrum of aspects. Further, artifact design heuristic of analogical design [27] is used to adopt the concept of cloud blueprints of Papazoglou [47] to the logistics domain.

Cloud Logistics Service Blueprints

The CLSB are virtual representations of the real logistics services offered by several LSP of the network. The objective is to connect services from several providers easily during planning, re-scheduling, etc., by their virtual representatives. Approaches and patterns for the actual integration from the modules to the IT-systems of the LSP can be found in Hohpe and Woolf [91]. They are not the focus of this research, but are the general concepts of the blueprints of CL. Following the approach of Papazoglou's cloud blueprints [47], different description languages (request, description, compliance and manipulation) are conceptualized that cover different aspects of the CLSB.

The *request language* is aligned with the ODP. As the semantic aspects have been modeled with the ontology design pattern described in OWL, logistics services can be requested via SPARQL queries on the technical side. In order to enable usability, those queries should be created with the help of graphically supported editors (see next section). Taken the above mentioned ODP, an example query to find logistics services for truck unloading from LSP that provide staff, forklifts and scanners in order to unload a truck and send information about the received goods digitally to a WMS would be as follows:

```
@prefix LoSe_ODP: <https://github.com/Michael-Gloeckner/LoSe_ODP#>
SELECT LogisticsStakeholder LogisticsService
FROM <https://github.com/Michael-Gloeckner/LoSe_ODP#>
WHERE {
LoSe_ODP:staff rdfs:subClassOf LoSe_ODP:Resource.
LoSe_ODP:forklifts rdfs:subClassOf LoSe_ODP:Resource.
LoSe_ODP:scanners rdfs:subClassOf LoSe_ODP:Resource.
LoSe_ODP:Resource LoSe_ODP:hasCharacter LoSe_ODP:Physical.
LoSe_ODP:Resource LoSe_ODP:isProvidedBy LoSe_ODP:LogisticsStakeholder.
}
```

The *description language*, just like OWL of the ODP, should be based on XML as well. The consolidated concept is presented in Figure 5. Conceptual content of the description should be focusing on domain specific aspects. Again, the *7 R of logistics* [86] (i.e. right product, location, time, quality, quantity, price, and information) are taken into account for the basic transformations of logistics services in accordance with the ODP. Those basic transformations of the logistics domain are known to LSP independent of IT skills, and thus create easy recognition and usage of the CLSB when used in the graphical representation. Domain specific flows match with the ones described in the ODP, i.e. flows of goods, information and control [14, 51]. Financial flow, which is also important in logistics [92], can be viewed in a wider sense, as a kind of information flow in regards to online banking (even though there might be higher formal and security requirements). CL is an information-centric paradigm; hence the flows of information and control are obligatory. The flow of goods is always the final objective of logistics services, but not always necessary (e.g. customs clearance via electronic systems or transport management). As described in the ODP, several types of resources are to be described and presented by the module (i.e. active vs. passive resources and informational vs. physical ones). A common point of quality management are the *SLA* in logistics. Their character and content depends strongly on the type of logistics service and thus forms a varying point, examples are: lead time, delivery rate, reliability, picking accuracy.

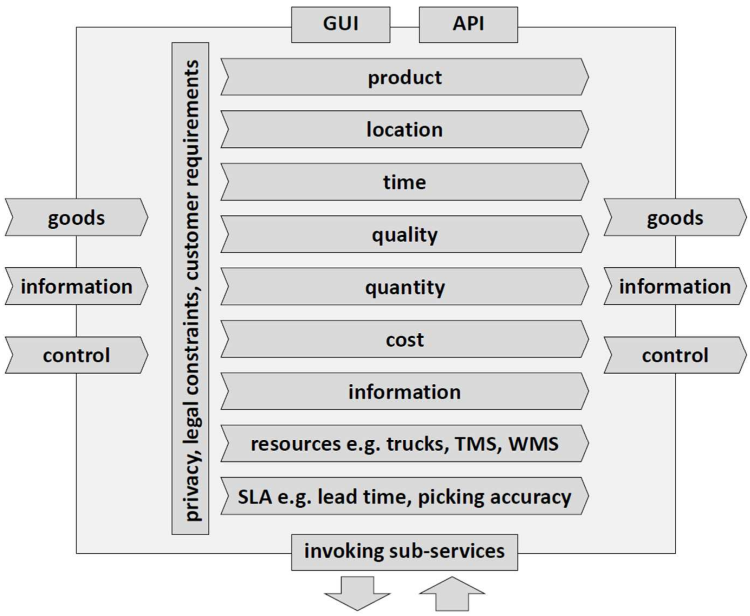

Figure 5: Conceptualized cloud logistics service blueprint as the generic basis for cloud logistics services.

The *compliance langauge* has to be able to represent the following aspects: Privacy, an important issue in logistics and requiring its own research [93, 94] especially in terms of cloud-based BPaaS [95], and the constraints that have been included in the ODP, such as the legal (restricted driving schedule [88] or permission to handle dangerous goods [87]) and consumer posed, non-legal, constraints [80].

The *manipulation language* is following the example of Papazoglou with the typical manipulation operators, e.g. match, merch, compose, delete, extract, disjoint, etc.

In summary, with the discussed modules containing a semantic core and a domain-proximal representation that is easily understandable to domain specialists, the foundation is created for a system utilizing a basic set of building blocks of logistics services. Those building blocks represent the generic logistics services that are to be customized when creating real life services from different LSP that can be represented in a common schema. Hence, the connection of services from different providers with differing systems is enabled on a virtualized level. With these concepts, logistics services can be engineered that enable the paradigm of cloud logistics. Subsequently, the next challenge is an appropriate framework for their convenient management.

The Service Map - Management

This sub-section focuses on the management of Cloud Logistics Service Blueprints within a logistics network via the conceptual framework of the logistics service map and its metamodel.

Logistics Service Map Concept

The Logistics Service Map concept needs to fulfill certain requirements. Retrieval of services is a challenging task [96, 97], especially for users with low IT-skills, such as small and medium LSP [98]. An intuitive and context-specific approach can help support the adoption of the service oriented paradigm and the cloud logistics paradigm in regards to small and medium LSP, respectively. Relations between services play a special role in logistics (e.g. see [87]) and in service networks in general [99]. Thus, the service map must structure and categorize the logistics services in a context-driven way. The handling of different granularity levels [100, 101] is useful in the context of services and composed services. Flexibility and agility are highly expected within the shipper-LSP relationship to accommodate current and future business challenges [15].

The Logistics service map concept satisfies the needs for support, especially the management of logistics service by offering a customizable framework. The objective is the domain-specific categorization and structuring of logistics services. The service map is defined as follows [39]:

A Service Map (SM) is a representation, in multiple abstraction layers, of existing services and their relations in a service network or part of it. The SM offers the functionality of a modular service system and is built upon machine-readable service description. It includes visualization and its purposes are precise mediation and collaborative planning, especially in a network based on the division of labor. The SM can be structured by a user-defined categorization-pattern.

The service map concept consists of two main parts, as seen in Figure 6. The first important aspect is the service catalog. Atomic services can be put into customizable categories of the catalog. Those categories help with retrieving atomic services with a structured categorization-pattern. Further, service templates are offered from which provider-specific services can be derived and then used to facilitate the service subscriptions of new LSP and/or services in the network. Templates consisting of composite services can also be stored in the catalog. Moreover, the available set of services within a network and the visualization foster a precise mediation and communication between all stakeholders during the whole service life-cycle. The unique standard of buildings blocks, i.e. the CLSB, interconnects services and resources from different providers. The second important part is the construction system. From the catalog, services can be selected and composed within the construction system in order to create composite services. Customer demands can be met by individually composing services following the customer-specific requirements during planning and re-scheduling. Further, the service map is able to display different granularity levels and viewpoints, from a basic service description up to an overview of services involving several categories.

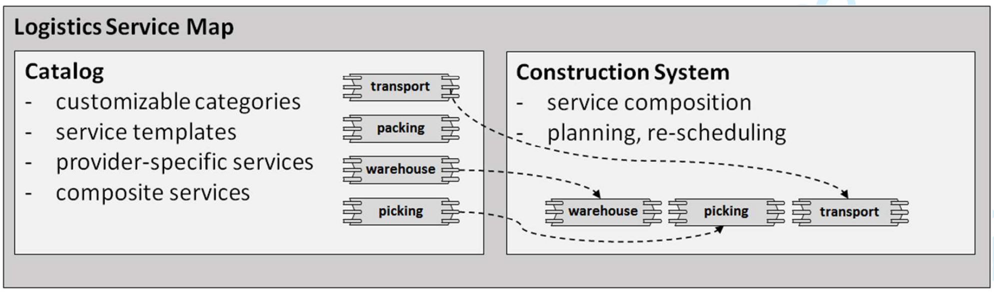

Figure 6: The logistics service map concept and its main constituent parts.

The usage of the logistics service map can be described with several use cases. (a) Add a new LSP to the network and match its offered services to the existing set of services in a logistics network by adding the new LSP to the provider list of the particular service. (b) Develop a new composite service to meet a specific customer's needs by selecting and composing services from the service catalog with the help of the editor. (c) Find a compensational service or provider when realizing the urgency for re-scheduling, re-planning or elimination of errors because of an unpredictable disturbance in the network. (d) Detect the need to find further specialists when customer requirements cannot be matched to existing services. Hence, the service map holds advantages for several stakeholders of a logistics network. On one hand, there is the network, the logistics integrator, and its customers that benefit from an easy management of logistics services. On the other hand, there is the possibility of easy participation of LSP in a dynamic network. The service map concept seeks to align both perspectives in order to foster mediation through a common set of services.

Metamodel

The service map concept is translated into an IT concept with the help of a model-driven development approach. Important requirements of model-driven development are emphasized by Atkinson and Kühne [33], outlining the capabilities and potential of metamodeling. First of all, metamodeling enables the long-term productivity of software artifacts with several benefits. One benefit is the easing of understanding for different stakeholders in case of staff change (personnel aspect). In the case of integrating new features, capabilities and changes in functional requirements, the effort of maintenance is reduced (functional aspect). The general operational concept can be modeled and implemented in different platforms, and still, interoperability is enabled on a common basis, i.e. the common metamodel, as artifacts are decoupled from tools (platform aspect). Therefore, a metamodel is an important basic artifact for IT-artifacts and other concepts. It is especially important in the domain of logistics networks that consist of a high amount of LSP due to outsourcing and the division of labor [15] (personnel aspect), with a dynamic range of offered and operated logistics services [102] (functional aspect), and a high variety of included systems and descriptions [15, 18] (platform aspect). Issues concerning versioning, inconsistencies, and independent maintenance of models and metamodels, can be faced with the help of specialized metamodel-platforms [103, 104].

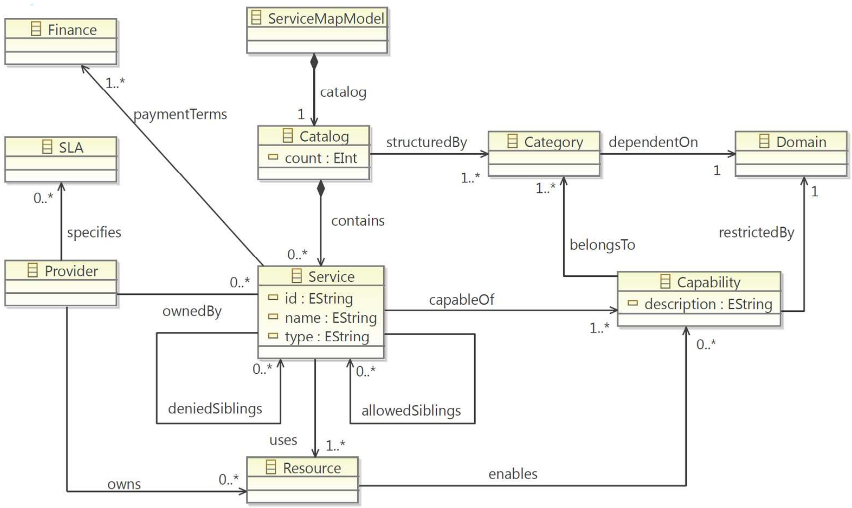

Figure 7: Metamodel of the Service Map.

The presented metamodel of the logistics service map, see

Figure 7, is based on the EMOF (Essential Meta Object Facility) compatible Ecore11 metametamodel. Nevertheless, the metamodel, and instances of it, could also be implemented in other frameworks. Instances of the logistics service map for different networks or different parts or portfolios of a network can be derived from the common metamodel. Hence, those instances are inter-connectable. The metamodel is adaptable and thus, there is no need to raise claim of completeness. Analogical to the ODP, the metamodel forms a trunk, or pattern, in order to give guidance and a starting point when creating a service map model.

Each instance of the metamodel consists of exactly one *catalog* containing services available in the network. This catalog is structured by *categories* which depend on a specific *domain* (e.g. logistics in the current case). The catalog represents a structured list of *services*, each capable of one or more *capabilities*. These capabilities are restricted by the domain of

[11] http://www.eclipse.org/modeling/emf/?project=emf

application and belong to certain categories. A *Provider* owns specific *resources* that are consumed during service provision. However, most logistics resources are still available after consumption, e.g. trucks and warehouses. *SLA* are specified by the providers as services can be merged with some other services and restricted in not working with others. As stated in [87], each service's relations and references composition possibilities to other services, can be described by *allowedSiblings* and *deniedSiblings*.

Because the logistics service map follows a metamodel based approach, an integrator is enabled to manage multiple provider networks independently but based on the same pattern, e.g. in automotive industry, chemical industry. Requirements of OEMs (Original Equipment Manufacturers) are very strict in that they often demand closed supply chains. Providers are not allowed to share their resources, such as warehouses, between different contracts. For instance, an integrator responsible for warehouses with vendor managed inventory (VMI) for multiple OEMs at nearby production sites is liable to provide warehouse resources to each of the OEMs exclusively, i.e. separate infrastructure and employees. With this in mind, an integrator is still able to optimally allocate resources if he partitions its complete network into independent parts and manages each of them separately. Though, same services are in different catalogs, the integrator is aware of the total resources available and can create an efficient supply chain for each customer while optimizing both owned and LSPs' assets.

Merging of Concepts – the Lego Brick System of Cloud Logistics

Bringing all the above described artifacts together, their relation and collective abilities are briefly outlined. On the one hand, there is the *service landscape*. The developed generic ontology design pattern is the semantic core of the designed generic cloud logistics service blueprints. Together, those two artifacts form the generic building blocks of cloud logistics and enable the standardized engineering of logistics services. On the other hand, there is the *service map*. The designed concept and its created metamodel serve for managing the logistics services in networks. The customizable categorization allows for easy retrieval of logistics service and their subsequent composition. The derived instances, i.e. logistics services, can be integrated and related to each other when relating to the common metamodel. Finally, bringing landscape and map together enables integrated logistics service engineering and management. Domain-specific objects of the metamodel are existent in the ODP as well, meaning the map is able to display the landscape and to support 'navigation' in it. The CLSB and the service map, enable a system of modular logistics services on the basis of cloud principles.

Evaluation

Following the design and merging of artifacts in the former section, this section introduces the FEDS method. The designed evaluation episode is applied to the above mentioned concepts in order to evaluate their power to answer the leading research question from the introduction: *"How should a logistics service system be designed as to adopt cloud principles?"*

The FEDS Method

Evaluation of design artifacts is a key activity in design science research [19, 35]. Characteristics of the evaluation are rather *summative* [105] and done *ex post* [106]. The leading approach is the Framework for Evaluation in Design Science Research (FEDS) [35]. Within the framework's first dimension, the *functional purpose* [35, 105] declares why artifacts are evaluated. This evaluation will be located between formative and summative. The outcome of the process of shifting logistics networks to the cloud logistics paradigm shall be improved and the evaluation is done to provide a basis for successful action (formative). Simultaneously, it shall be checked whether the outcomes match the expectations and if a consistent interpretation across is to be created, similar to a standard (summative). Evaluation shifts over time, from being rather formative to rather summative, depending on the state of development [35]. The developed artifacts are the first conceptualized models that create the building blocks for the paradigm of cloud logistics. Thus, both purposes are partly fulfilled.

The framework's second dimension, the *paradigm of the study* [35], declares how artifacts are evaluated (i.e. either artificially or naturalistically). Again, the evaluation falls between the two. The evaluation does not adhere to real users nor real systems, which is why it cannot be seen as fully naturalistic [107]. Nevertheless, real process descriptions are used in order to conduct a criteria-based evaluation with theoretical arguments [108], thus providing partial fulfillment. Venable et al. [35] presents four particular steps for a successful evaluation in design science research:

(1) Explicate goals: The goal of the evaluation is *rigor*. It shall be shown that the artifacts are collectively able to enable the cloud logistics paradigm and work in real situations. Therefore, real process descriptions are taken into account.

(2) Choose evaluation strategy: Technical risks (e.g. integration engineering) as well as user-oriented risks (e.g. usability) are relatively low. Hence, a Quick & Simple strategy is emphasized to be suitable. Further, the described purpose and paradigm of evaluation described above also argues for a Quick & Simple strategy. Costs for a fully naturalistic evaluation would be very high when transforming whole network portfolios. Prototyping is suggested by Venable et al. [35] as a first evaluation step, for such a case.

(3) Determine properties to evaluate: As the results are made from a conceptual basis for a complex piece of software, the generic artifact properties of Mathiassen [109] apply, which are based on the standard ISO 9126. The properties of being 'flexible', 'comprehensible', 'reusable', and 'interoperable' are taken into account, as they mark the essential advantages of the new paradigm of cloud logistics [44]. Mainly, the basic cloud principles from Table 1 will provide evidence of the artifacts enabling of the CL paradigm. Venable et al. also recommend the framework of Smithson and Hirschheim [110] for the evaluation of artifacts embodying

information systems. Thus, a ‘comparison with objectives’ is the superior property of evaluation.

(4) Design the individual evaluation episode(s): As resources for the concurrent research project are limited (i.e. time, people, and budget) and former discussions lead unanimously to the Quick & Simple strategy, one evaluation episode will be described. As the developed artifacts are still in an early and very conceptual state, one episode is assumed to be sufficient.

Quick & Simple Evaluation Episode

Taking the framework of Smithson and Hirschheim into account, the leading approach is the *comparison with the objectives*, which is taken from Mathiassen. Those objectives are discussed in the following with the final prototype supporting the arguments. Also, the objectives are discussed for each of the four designed artifacts, i.e. ontology design pattern (ODP), cloud logistics service blueprint (CLSB), service map concept (SM), and the service map metamodel (MM), as well as an incorporated discussion of the Lego Brick System of Cloud Logistics.

Flexible

The generic character of ODP, CLSB, MM, and their design with regards to basic domain-specific requirements enable the creation of a comprehensive range of logistics services. The SM concept is customizable by definition and can then be configured in a flexible way. The *Lego Brick system*, consisting of reusable service templates, allows for a flexible planning and re-scheduling of composite logistics services. Due to the de facto standardized interface concepts of the building blocks (i.e. goods, information, and control) modules can be flexibly added, removed, or exchanged in composite services.

Comprehensible

Each presented artifact is developed with regards to basic domain-specific requirements (such as basic transformations, flows, or resource descriptions). Domain experts should be able to understand and determine specifics of the service for either subscription of own services to the service map, or to select appropriate services from the catalog. The *Lego Brick system,* as a whole, enables the easy creation and combination of modules that contain logistics functions and basic services in the style of the well-known toy 'Lego'. With this approach, complex services and customized supply chains can be created easily due to building blocks and their connecting interfaces.

Reusable

Again, due to the generic character, each of the designed artifacts can be re-used to create a wide ranging portfolio of logistics services. The *Lego Brick system* consists of reusable service templates, from which instantiations for each LSP can be derived and stored in the catalog of the service map. The development of further reusable templates is also possible.

Interoperable

A basic principle of a semantic approach is the management of and reasoning on existing knowledge without regards to actual syntax and description language. By relying on a central ODP and domain-specific interfaces, the created Lego Bricks are interoperable and can be exchanged easily. The *Lego Brick system* remains to be in a very conceptual state. Therefore, integration with other IT systems, e.g. of the related LSP, is still an issue to be solved in future research activity. First ideas for patterns and concepts that solve this can be found in [91].

User Access (CL-specific)

With stable interfaces (from ODP, CLSB) easier access and reconfiguration is achieved. Further, machine-readability supports (semi-)automated service engineering and management.

Resource Heterogeneity, Virtualization and Sharing (CL-specific)

With the help of interoperable and reusable building blocks and virtualized resources (ODP, CLSB), the actual resources can be hidden behind a developed interface in the *Lego Brick* *system*. This means resources can be shared more easily within a logistics network, especially commodity services (e.g. transportation, warehousing).

Standardization (CL-specific)

With the help of the building blocks and service map artifacts, a standardization can be reached for the modules (i.e. ODP, CLSB) and for the structuring and categorization of logistics services within the catalog (i.e. SM, MM). Even though generic, the *Lego Brick system* still remains very flexible by including common and varying points of the logistics domain.

Scalability and Resource Optimization (CL-specific)

Standardized interfaces and reusable modules (i.e. ODP, CLSB) grant flexibility. Scalability and reorganization of resources, which are prerequisites of optimization, is enabled. Under the assumption of a satisficing amount of available real resources in the network, the *Lego Brick system* scales easily.

Payment Model (CL-specific)

Pay-per-use payment models have been possible since before CL. Financial aspects are included into the concepts of CLSB and MM. The *Lego Brick system* with a continuous support of information systems facilitates invoicing and actual payments.

Service Level Agreements (CL-specific)

SLA are formalized and included in ODP, CLSB, and MM. Thus, an integration and interchange within, and between, the service landscape and service map is possible. Further, this enables the consistent implementation of SLA for the whole *Lego Brick system*.

Prototype

The prototype of the Lego Brick system has been developed and implemented as a general proof of concept and as a helpful tool to gain further insights during development [111].

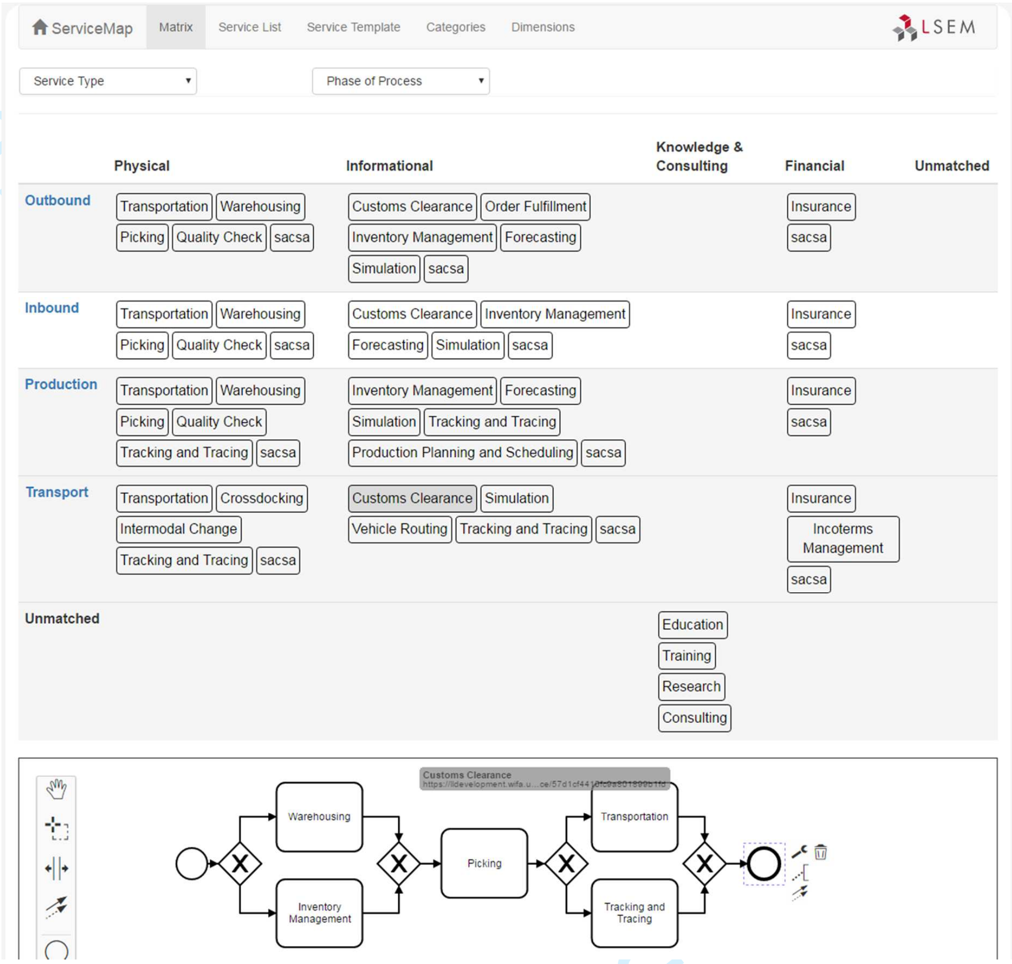

Figure 8: Screenshot of the prototype.

The Screenshot in Figure 8 shows the current state of the web-based prototype. On top there is the navigation bar with (from left to right) the matrix view of the catalog, service list (instantiations of the templates), service templates, as well as categories and dimensions in order to customize the catalog structure. In the figure, the matrix view of the catalog is displayed with the two dimensions of ‘service type’ (comprising of characteristics like physical or informational services, as well as knowledge-intensive and financial focused logistics services) and ‘phase of process’ (i.e. the logical order from outbound via transport to inbound and the next downstream production). The selected dimensions of the matrix can be changed via drop down menu. The editor canvas for the composition of complex logistics services is located right under the matrix. For the sake of pragmatism, in the prototype the (logistics) services are interpreted as tasks of processes. In order to have a high and widespread acceptance, the standard of BPMN 2.0 [112] has been used and implemented with the help of the web-based BPMN editor[12]. For ease of use, services can be placed on the editor canvas via drag and drop. As seen in figure 8, the example of a complex service from Figure 6 is rebuilt, consisting of warehousing, picking and transportation. The service description in the prototype is based on the concept presented by ODP and CLSB. The composite services are saved in XML, e.g. see Figure 9. In the example, IDs and names of services are displayed. Further, the position on the canvas and the relations between several process tasks are encoded. With this format, information about services can be transferred easily as machine-readable files between several stakeholders. With the help of the web-based prototype, LSP are enabled to view details and information about the (complex) services with standard IT systems and even smartphones via web browser.

Two example processes of the logistics domain, from two real internationally operating LSP, are anonymized (due to privacy reasons) and they are modeled with the help of the Lego Brick system proofing the concept. The goal is to create logistics services that can be easily connected, even though they are offered by different LSP with different description standards. This represents a realistic scenario in a logistics network characterized by specialization and division of labor. Such a network could be managed (planning, controlling, monitoring) with the help of the Lego Brick system.

[12] https://bpmn.io/


```xml
Evaluation.xml
<?xml version="1.0" encoding="UTF-8"?>
<bpmn2:definitions xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:bpmn2="http://www.omg.org/spec/BPMN/20100524/MODEL" xmlns:bpmnd
  <bpmn2:process id="Process_1" isExecutable="false">
    <bpmn2:startEvent id="StartEvent_1">
      <bpmn2:outgoing>SequenceFlow_1tb4927</bpmn2:outgoing>
      <bpmn2:outgoing>SequenceFlow_0kr59uj</bpmn2:outgoing>
    </bpmn2:startEvent>
    <bpmn2:task id="service147646040306957d1d3b810fc9a801899b209" name="Warehousing">
      <bpmn2:incoming>SequenceFlow_1tb4927</bpmn2:incoming>
      <bpmn2:outgoing>SequenceFlow_1opqtyh</bpmn2:outgoing>
    </bpmn2:task>
    <bpmn2:task id="service147646041093757d1ce3c10fc9a801899b1fb" name="Inventory Management">
      <bpmn2:incoming>SequenceFlow_026skqt</bpmn2:incoming>
    </bpmn2:task>
    <bpmn2:task id="service147646041276957d1cd0010fc9a801899b1f7" name="Picking">
      <bpmn2:incoming>SequenceFlow_0kr59uj</bpmn2:incoming>
      <bpmn2:outgoing>SequenceFlow_026skqt</bpmn2:outgoing>
    </bpmn2:task>
    <bpmn2:task id="service147646041875657d1d0ef10fc9a801899b200" name="Transportation">
      <bpmn2:incoming>SequenceFlow_1opqtyh</bpmn2:incoming>
    </bpmn2:task>
    <bpmn2:sequenceFlow id="SequenceFlow_1tb4927" sourceRef="StartEvent_1" targetRef="service147646040306957d1d3b810fc9a801899b209" />
    <bpmn2:sequenceFlow id="SequenceFlow_1opqtyh" sourceRef="service147646040306957d1d3b810fc9a801899b209" targetRef="service147646041875657d1
    <bpmn2:sequenceFlow id="SequenceFlow_026skqt" sourceRef="service147646041276957d1cd0010fc9a801899b1f7" targetRef="service147646041093757d1
    <bpmn2:sequenceFlow id="SequenceFlow_0kr59uj" sourceRef="StartEvent_1" targetRef="service147646041276957d1cd0010fc9a801899b1f7" />
  </bpmn2:process>
  <bpmndi:BPMNDiagram id="BPMNDiagram_1">
    <bpmndi:BPMNPlane id="BPMNPlane_1" bpmnElement="Process_1">
      <bpmndi:BPMNShape id="_BPMNShape_StartEvent_2" bpmnElement="StartEvent_1">
        <dc:Bounds x="200" y="240" width="36" height="36" />
      </bpmndi:BPMNShape>
      <bpmndi:BPMNShape id="Task_1laaljw_di" bpmnElement="service147646040306957d1d3b810fc9a801899b209">
        <dc:Bounds x="400.6" y="122" width="100" height="80" />
      </bpmndi:BPMNShape>
```


Figure 9: XML code of a complex service.

LSP 1 offers the service 'picking for long-distance transport' within the network. This comprises all physical entity movements to the truck and follows the steps of (1) getting freight documents from WMS, (2) scanning, (3) picking, (4) bringing pallets to the vehicle, (5) loading pallets onto the vehicle, and (6) scanning and forwarding protocol to WMS. The input flows are informational (freight document: goods identification, quantity, shipper, consignee) and physical (order position, pallets containing goods, vehicle). The control flow is added later on, when the logistics service is composed with other services. The trigger signal would be the arriving of the order at the warehouse. The transformations aim at the dimensions of location (warehouse to vehicle), time (the process takes a certain amount of time), costs (occurring for the provision of the service), and information (state of the order positions, pallet containing a certain good changes from ‘in warehouse’ to ‘in transfer’, and the location information is changed as well). The necessary resources for this comprise staff, forklifts, transport vehicle, scanners, WMS (active), pallet, and freight documents (passive). Important KPI and SLA comprise the time consumed, the accuracy of identification of goods, identification of pallet space and the matching of the latter two. For the forwarding of the protocol that contains the transformations done, electronic web services could be used for information transmission to the logistics integrator.

LSP 2 offers the service 'long-distance transportation' within the network. This comprises the steps of (1) picking up load units (e.g. pallets) from origin, (2) signing receipt of goods, (3) conduct transportation of goods to destination, (4) delivery of goods to destination, and (5) get confirmation of receipt. The input flows are informational (order information) and physical (truck and pallets). The control flow is added later on as well. The transformations aim at the dimensions of location (goods from origin to destination), time, quantity, cost, and information (state of the goods from origin to destination). The necessary resources for this comprise staff, truck (active), pallet, loading document, and freight document (passive). Important KPI and SLA comprise the lead time and fuel consumption. Electronic services are invoked to transfer data.

Service 1 could be categorized with the attributes physical, outbound, picking. Service 2 could be characterized with the attributes physical, transportation. One crucial difference between both descriptions is the name for the transport mean. LSP 1 names it ‘vehicle’, whereas LSP 2 puts the label ‘truck’ on it. At the time of subscription of the service to the logistics network through the service map, a semantic link has to be established. For example, both resources could be comprised by the superior class of ‘active road transport resource’ with the help of the ontological *sameAs* property.

The goal of the evaluation was to show rigor. The artifacts collectively enable the principles of the cloud logistics paradigm and have shown the applicability in real situations with the help of anonymized real process descriptions. The prototype further proved the technical feasibility of the concepts.

Conclusion

Summary

The paper's purpose is to take a first step towards a digitalized logistics industry as an important part of digitalized SCM or SCM 4.0, respectively. By adopting cloud principles to logistics and creating generic basic modules of logistics services, the digital interconnection of LSP as well as the basis for connecting sensors and analytics to logistics services is facilitated. Logistics forms an essential part of supply chains and SCM in terms of the physical and non-physical services related to the physical movement of goods in the supply chain. Hence, with a digitalized logistics a first step towards digital business strategies in SCM can be realized in order to interact and serve a digitalized manufacturing and production industry.

The primary focus of this paper is on the first steps towards comprehensive conceptual elaboration of the cloud logistics paradigm. The disruptive character of cloud computing and its influence on other industries is shown by outlining the parallels of computing services and logistics services. Simultaneously, the gaps in research and the resulting necessity of further development have been derived. With the help of design science research and design-oriented information systems research, the leading research question is answered. Design oriented conceptual IT artifacts have been developed in order to make cloud principles adoptable to the logistics domain. An ontology design pattern is developed in order to describe logistics services (as well as their resources) semantically, making the connection of services from different LSP possible, independent from the description standard. Further, a generic logistics service module as a basic platform for digitalized logistics services and the connection of sensors and analytics is developed with the cloud logistics service blueprint. With the artifact of the logistics service map and its metamodel, a conceptual framework is designed for structuring and categorizing logistics services in order to facilitate their management. After merging the artifacts, the collective approach is evaluated with the FEDS framework. Anonymized real logistics process descriptions have been used to show the conceptual, as well as the technical feasibility of the approach. Emphasis is put on cloud logistics centered evaluation criteria, such as user access, resource heterogeneity, resource virtualization, standardization, and scalability.

Theoretical Implications

With the artifacts presented in this paper, a first bundle of IT-related concepts has been developed and evaluated for the support and enabling of cloud logistics in the context of digitalized supply chains. An important contribution is the first explicit definition of cloud logistics that is derived by systematically reviewing the state of the art literature of cloud logistics. Also, the integration of the two existing streams of cloud computing centric layers on cloud logistics (i.e. IaaS, PaaS, SaaS) *and* resource-centric layers (i.e. logistics resources, virtualized resources, encapsulated resources (=services)) have been combined for the first time, by extending the existing framework of cloud logistics. With the help of a design oriented research approach, artifacts have been developed, creating a comprehensive starting point for future research on cloud logistics and digitalized supply chains.

Practical Implications

Practitioners get an overview of the potential and possibilities of the new paradigm in logistics. General conceptual approaches are presented. LSP are motivated to open up to digitalized approaches in order to stay competitive. Outsourcing and insourcing of capabilities, processes, and resources is nothing new to logistics, however, LSP should shift from being closed and striving only for competitive advantages, towards increased collaboration, transparency and flexibility in terms of virtualizing their resources. The disruptive paradigm of CL with its inherent digitization opens a chance for increasing specialization, providing higher service quality, and boosting customer satisfaction with more flexible solutions and higher ease of use. These qualities will lead to better success on the market serving a digital production industry.

Limitations and Further Research

As the paper presents the first conceptual steps of dedicated cloud logistics artifacts, there is still a high number of aspects that demand for further research. The artifacts and the Lego Brick system need to be refined and further evaluated with a higher number of real logistics processes in a more complex network. This also implies further episodes of evaluation employing the FEDS framework. Indeed, an embedding of those cloud logistics services within a digitalized production network would lead to further insights and improvements.

Acknowledgment

The work presented in this paper was funded by the German Federal Ministry of Education and Research within the project Logistik Service Engineering und Management (LSEM). More information can be found under the reference BMBF 03IPT504X (lsem.de).

References

1. Hofmann, E., Rüsch, M.: Industry 4.0 and the current status as well as future prospects on logistics. Computers in Industry 89, 23–34 (2017)
2. Bharadwaj, A., El Sawy, O.A., Pavlou, P.A., Venkatraman, N.: Digital Business Strategy: Toward a next Generation of Insights. MIS Quarterly 37, 471–482 (2013)
3. Alicke, K., Rexhausen, D. and Seyfert, A.: Supply chain 4.0 in consumer goods, https://www.mckinsey.com/industries/consumer-packaged-goods/our-insights/supply-chain-4-0-in-consumer-goods
4. Klötzer, C., Pflaum, A.: Toward the Development of a Maturity Model for Digitalization within the Manufacturing Industry s Supply Chain. In:. Hawaii International Conference on System Sciences (2017)
5. Stölzle, W., Hofmann, E., Oettmeier, K.: Fokusstudie "SCM 4.0: Supply Chain Management und digitale Vernetzung". GS1 Schweiz, Bern (2017)
6. Richey, R.G., Morgan, T.R., Lindsey-Hall, K., Adams, F.G.: A global exploration of Big Data in the supply chain. Int Jnl Phys Dist & Log Manage 46, 710–739 (2016)
7. Wieland, A., Handfield, R.B., Durach, C.F.: Mapping the Landscape of Future Research Themes in Supply Chain Management. Journal of Business Logistics 37, 205–212 (2016)
8. Glöckner, M., Ludwig, A., Franczyk, B.: Go with the Flow - Design of Cloud Logistics Service Blueprints. In: Proceedings of the Annual Hawaii International Conference on System Sciences (HICSS), pp. 5058–5067 (2017)
9. Marston, S., Li, Z., Bandyopadhyay, S., Zhang, J., Ghalsasi, A.: Cloud computing — The business perspective. Decision Support Systems 51, 176–189 (2011)
10. Gupta, P., Seetharaman, A., Raj, J.R.: The usage and adoption of cloud computing by small and medium businesses. International Journal of Information Management 33, 861–874 (2013)

11. Erl, T.: SOA. Principles of service design. Prentice Hall, Upper Saddle River, NJ (2008)
12. Mell, P., Grance, T.: The NIST definition of cloud computing. Computer Security Division, Information Technology Laboratory, National Institute of Standards and Technology Gaithersburg (2011)
13. Knipp, E.: Don't Bring a Differentiated Knife to a Commodity Gun Fight, https://blogs.gartner.com/eric-knipp/2012/03/06/dont-bring-a-differentiated-knife-to-a-commodity-gun-fight/
14. Gudehus, T., Kotzab, H.: Comprehensive Logistics. Springer Berlin Heidelberg, Berlin, Heidelberg (2012)
15. Langley, J., Long, M.: 2016 Third-Party Logistics Study. The State of Logistics Outsourcing. Results and Findings of the 20th Annual Study 20 (2016)
16. Lai, K.-h., Wong, C.W.Y., Cheng, T.C.E.: Bundling digitized logistics activities and its performance implications. Industrial Marketing Management 39, 273–286 (2010)
17. Kagermann, H.: Change Through Digitization—Value Creation in the Age of Industry 4.0. In: Albach, H., Meffert, H., Pinkwart, A., Reichwald, R. (eds.) Management of permanent change, pp. 23–45. Springer Gabler, New York (2015)
18. Wilding, R., Juriado, R.: Customer perceptions on logistics outsourcing in the European consumer goods industry. Int Jnl Phys Dist & Log Manage 34, 628–644 (2004)
19. Hevner, A., March, S., Park, J., Ram, S.: Design Science in Information Systems Research. MIS Quarterly 28, 75–105 (2004)
20. Gregor, S., Hevner, A.: Positioning and presenting design science research for maximum impact. MIS Quarterly 37 (2013)
21. Österle, H., Becker, J., Frank, U., Hess, T., Karagiannis, D., Krcmar, H., Loos, P., Mertens, P., Oberweis, A., Sinz, E.J.: Memorandum on design-oriented information systems research. Eur J Inf Syst 20, 7–10 (2010)
22. Newell, A., Simon, H.A., others: Human problem solving. Prentice-Hall Englewood Cliffs, NJ (1972)
23. Wickelgren, W.A.: How to solve problems;. Elements of a theory of problems and problem solving. W.H. Freeman, San Francisco (1974)
24. Vom Brocke, J., Simons, A., Riemer, K., Niehaves, B., Plattfaut, R., Cleven, A.: Standing on the Shoulders of Giants: Challenges and Recommendations of Literature Search in Information Systems Research. Communications of the Association for Information Systems 37, 205–224 (2015)
25. Smith, G.F.: Towards a heuristic theory of problem structuring. Management science 34, 1489–1506 (1988)
26. Simon, H.A., Langley, P.W., Bradshaw, G.L.: Scientific discovery as problem solving. Synthese 47, 1–27 (1981)
27. Goel, A.K.: Design, analogy, and creativity. IEEE Expert 12, 62–70 (1997)
28. Rowe, P.G.: Design thinking. MIT press (1991)
29. Smith, G.F.: Towards a theory of managerial problem solving. Decision Support Systems 8, 29–40 (1992)
30. Hara, T., Arai, T., Shimomura, Y., Sakao, T.: Service CAD system to integrate product and human activity for total value. CIRP Journal of Manufacturing Science and Technology 1, 262–271 (2009)
31. Czarnecki, K., Eisenecker, U.: Generative programming. Methods, tools, and applications. Addison Wesley, Boston (2000)
32. Ritchey, T.: General Morphological Analysis - A general method for non-quantified modelling, http://www.swemorph.com/pdf/gma.pdf
33. Atkinson, C., Kuhne, T.: Model-driven development: a metamodeling foundation. IEEE Software 20, 36–41 (2003)
34. Briggs, R.O., Nunamaker, J.F., Sprague, R.: Special Section Applied Science Research in Information Systems. The Last Research Mile. Journal of Management Information Systems 28, 13–16 (2011)
35. Venable, J., Pries-Heje, J., Baskerville, R.: FEDS. A Framework for Evaluation in Design Science Research. Eur J Inf Syst (2014)

36. Peffers, K., Rothenberger, M., Tuunanen, T., Vaezi, R.: Design Science Research Evaluation. In: Peffers, K. (ed.) Design science research in information systems. Advances in theory and practice : 7th international conference : proceedings, 7286, pp. 398–410. Springer, Heidelberg (2012)
37. Glöckner, M., Ludwig, A.: LoSe ODP - An Ontology Design Pattern for Logistics Services. In: Hitzler, P., Hammer, K., Solanki, M., Lawrynowicz, A., Nuzzolese, A., Krisnadhi, A. (eds.) Workshop on Ontology and Semantic Web Patterns (7th edition) (2016)
38. Glöckner, M., Augenstein, C., Ludwig, A.: Metamodel of a Logistics Service Map. In: van der Aalst, W., Mylopoulos, J., Rosemann, M., Shaw, M.J., Szyperski, C., Abramowicz, W., Kokkinaki, A. (eds.) Business Information Systems, 176, pp. 185–196. Springer International Publishing, Cham (2014)
39. Glöckner, M., Ludwig, A.: Towards a Logistics Service Map. Support for Logistics Service Engineering and Management. In: Blecker, T., Kersten, W., Ringle, C. (eds.) Pioneering solutions in supply chain performance management. Concepts, technologies and applications. Proceedings of the Hamburg International Conference of Logistics (HICL) 2013, 17, pp. 309–324. Eul, Lohmar, Köln (2013)
40. Vaquero, L.M., Rodero-Merino, L., Caceres, J., Lindner, M.: A break in the clouds. SIGCOMM Comput. Commun. Rev. 39, 50 (2008)
41. Leukel, J., Kirn, S., Schlegel, T.: Supply Chain as a Service. A Cloud Perspective on Supply Chain Systems. IEEE Systems Journal 5, 16–27 (2011)
42. Delic, K.A., Walker, M.A.: Emergence of the Academic Computing Clouds. Ubiquity 2008, 1 (2008)
43. Buyya, R., Yeo, C.S., Venugopal, S.: Market-Oriented Cloud Computing: Vision, Hype, and Reality for Delivering IT Services as Computing Utilities. In: 2008 10th IEEE International Conference on High Performance Computing and Communications (HPCC), pp. 5–13
44. Delfmann, W., Jaekel, F.: The Cloud - Logistics for the Future? Discussionpaper (2012)
45. Holtkamp, B., Steinbuss, S., Gsell, H., Loeffeler, T., Springer, U.: Towards a Logistics Cloud. In: 2010 Sixth International Conference on Semantics Knowledge and Grid (SKG), pp. 305–308 (2010)
46. Li, W., Zhong, Y., Wang, X., Cao, Y.: Resource virtualization and service selection in cloud logistics. Journal of Network and Computer Applications 36, 1696–1704 (2013)
47. Papazoglou, M.P.: Cloud Blueprints for Integrating and Managing Cloud Federations. In: Heisel, M. (ed.) Software service and application engineering. Essays dedicated to Bernd Krärmer on the occasion of his 65th birthday, 7365, pp. 102–119. Springer, Berlin (2012)
48. Schuldt, A., Hribernik, K., Gehrke, J.D., Thoben, K.-D., Herzog, O.: Cloud Computing for Autonomous Control in Logistics. In: GI Jahrestagung (1), pp. 305–310 (2010)
49. Wang, X., Li, W., Zhong, Y., Zhao, W.: Research on cloud logistics-based one-stop service platform for logistics center. In: 2012 IEEE 16th International Conference on Computer Supported Cooperative Work in Design (CSCWD), pp. 558–563 (2012)
50. Li, C., Zhang, X., Li, L.: Research on Comparative Analysis of Regional Logistics Information Platform Operation Mode Based on Cloud Computing. IJFGCN 7, 73–80 (2014)
51. Weißenberg, N., Springer, U.: Cloud Process Modeling for the Logistics Mall-Object-Aware BPM for Domain Experts. Open Journal of Mobile Computing and Cloud Computing 1, 31–49 (2014)
52. Zhong, Y., Li, W., Guo, W., Gong, L., Lodewijks, G.: A method of modeling and service encapsulation on cloud logistics resources. In: 2015 IEEE 19th International Conference on Computer Supported Cooperative Work in Design (CSCWD), pp. 383–388 (2015)
53. Zhang, S., Hu, X.: Game Analysis on Logistics Cloud Service Discovery and Combination. IJUNESST 8, 193–202 (2015)
54. Zhang, Y., Liu, S., Liu, Y., Li, R.: Smart box-enabled product–service system for cloud logistics. International Journal of Production Research, 1–14 (2016)
55. Leukel, J., Scheuermann, A.: Cloud Logistics ist mehr als Logistiksoftware aus der Cloud. Wirtsch Inform Manag 6, 38–45 (2014)
56. Lynn, T., O'Carroll, N., Mooney, J., Helfert, M., Corcoran, D., Hunt, G., van der Werff, L., Morrison, J., Healy, P.: Towards a framework for defining and categorising business Process-As-A-Service (BPaaS). In: 21st International Product Development Management Conference. Citations: Not Avail (2014)

57. Hinkelmann, K., Kritikos, K., Kurjakovic, S., Lammel, B., Woitsch, R.: A Modelling Environment for Business Process as a Service. In: Krogstie, J., Mouratidis, H., Su, J. (eds.) Advanced Information Systems Engineering Workshops. CAiSE 2016 International Workshops, Ljubljana, Slovenia, June 13-17, 2016, Proceedings, 249, pp. 181–192. Springer, Cham (2016)
58. Hitzler, P., Krötzsch, M., Rudolph, S.: Foundations of Semantic Web technologies. CRC Press, Boca Raton (2010)
59. Preist, C., Esplugas-Cuadrado, J., Battle, S.A., Grimm, S., Williams, S.K.: Automated Business-to-Business Integration of a Logistics Supply Chain Using Semantic Web Services Technology. In: Gil, Y. (ed.) The Semantic Web-- ISWC 2005. 4th International Semantic Web Conference, ISWC 2005, Galway, Ireland, November 6-10, 2005 : proceedings, 3729, pp. 987–1001. Springer, Berlin, New York (2005)
60. Stevenson, M., Spring, M.: Flexibility from a supply chain perspective. Definition and review. Int Jrnl of Op & Prod Mnagemnt 27, 685–713 (2007)
61. Staab, S., Studer, R.: Handbook on Ontologies. Springer Berlin Heidelberg, Berlin, Heidelberg (2009)
62. Gangemi, A.: Ontology Design Patterns for Semantic Web Content. In: Gil, Y. (ed.) The Semantic Web-- ISWC 2005. 4th International Semantic Web Conference, ISWC 2005, Galway, Ireland, November 6-10, 2005 : proceedings, 3729, pp. 262–276. Springer, Berlin, New York (2005)
63. Gangemi, A., Gómez-Pérez, A., Presutti, V., Suárez-Figueroa, M.C.: Towards a catalog of owl-based ontology design patterns (2007)
64. Blomqvist, E., Gangemi, A., Presutti, V.: Experiments on pattern-based ontology design. In: Gil, Y., Noy, N. (eds.) The fifth International Conference on Knowledge Capture, p. 41
65. Presutti, V., Gangemi, A.: Content Ontology Design Patterns as Practical Building Blocks for Web Ontologies. In: Li, Q. (ed.) Conceptual modeling - ER 2008. 27th International Conference on Conceptual Modeling, Barcelona, Spain, October 20-24, 2008 : proceedings, 5231, pp. 128–141. Springer, Berlin (2008)
66. Scheuermann, A., Leukel, J.: Supply chain management ontology from an ontology engineering perspective. Computers in Industry 65, 913–923 (2014)
67. Suárez-Figueroa, M.C., Gómez-Pérez, A., Fernández-López, M.: The NeOn Methodology for Ontology Engineering. In: Suárez-Figueroa, M.C., Gómez-Pérez, A., Motta, E., Gangemi, A. (eds.) Ontology Engineering in a Networked World, pp. 9–34. Springer Berlin Heidelberg, Berlin, Heidelberg (2012)
68. Presutti, V.: Content Ontology Design Pattern: time interval, http://www.ontologydesignpatterns.org/cp/owl/timeinterval.owl
69. Krisnadhi, A.: Content Ontology Design Pattern: material transformation, http://descartes-core.org/ontologies/mt/1.1/MaterialTransformationPattern.owl
70. Whitehead, B.: Content Ontology Design Pattern: TransportPattern, https://wiki.auckland.ac.nz/download/attachments/52016791/TransportPattern.owl
71. Madni, A.M., Lin, W., Madni, C.C.: IDEONTM. An extensible ontology for designing, integrating, and managing collaborative distributed enterprises. Syst. Engin. 4, 35–48 (2001)
72. Gonnet, S., Vegetti, M., Leone, H., Henning, G.: SCOntology. In: Cruz-Cunha, M.M., Cortes, B.C., Putnik, G. (eds.) Adaptive technologies and business integration. Social, managerial, and organizational dimensions, pp. 137–158. Idea Group Reference, Hershey PA (2007)
73. Zdravković, M., Panetto, H., Trajanović, M., Aubry, A.: An approach for formalising the supply chain operations. Enterprise Information Systems 5, 401–421 (2011)
74. Daniele, L., Ferreira Pires, L.: An ontological approach to logistics. In: M. Zelm, M.J. van Sinderen, G. Doumeingts (eds.) Enterprise Interoperability, Research and Applications in the Service-oriented Ecosystem, IWEI 2013, pp. 199–213. ISTE Ltd, John Wiley & Sons, Inc, Surrey, UK (2013)
75. Hoxha, J., Scheuermann, A., Bloehdorn, S.: An approach to formal and semantic representation of logistics services. In: Proceedings of the Workshop on Artificial Intelligence and Logistics (AILog), 19th European Conference on Artificial Intelligence (ECAI 2010), Lisbon, Portugal, pp. 73–78 (2010)
76. Engel, T., Bhat, M., Vasudhara, V., Goswami, S., Krcmar, H.: An Ontology-based Platform to Collaboratively Manage Supply Chains. In: 25th Annual Conference of the Production and Operations Management Society (POMS), pp. 1–10 (2014)

77. Scheuermann, A., Hoxha, J.: Ontologies for Intelligent Provision of Logistics Services. In: ICIW 2012 : The Seventh International Conference on Internet and Web Applications and Services, pp. 106–111 (2012)
78. Fayez, M., Rabelo, L., Mollaghasemi, M.: Ontologies for Supply Chain Simulation Modeling. In: Winter Simulation Conference, 2005, pp. 2364–2370 (2005)
79. Geerts, G.L., O'Leary, D.E.: A supply chain of things. The EAGLET ontology for highly visible supply chains. Decision Support Systems 63, 3–22 (2014)
80. Anand, N., Yang, M., van Duin, J.H.R., Tavasszy, L.: GenCLOn. An ontology for city logistics. Expert Systems with Applications 39, 11944–11960 (2012)
81. Wang, X., Wong, T.N., Fan, Z.-P.: Ontology-based supply chain decision support for steel manufacturers in China. Expert Systems with Applications 40, 7519–7533 (2013)
82. Chandra, C., Tumanyan, A.: Organization and problem ontology for supply chain information support system. Data & Knowledge Engineering 61, 263–280 (2007)
83. Li, D., Xue, X., Ding, S., Li, C.: OWL 2 Based Validation and Modeling of Logistics Domain Ontology. International Journal of Artificial Intelligence and Application for Smart Devices 2, 1–8 (2014)
84. Lusch, R.F., Vargo, S.L.: Service-dominant logic. Reactions, reflections and refinements. Marketing Theory 6, 281–288 (2006)
85. Grönroos, C.: Service management and marketing. A customer relationship management approach. Wiley, Chichester [u.a.] (2000)
86. Mentzer, J.T., Flint, D.J., Kent, J.L.: Developing a logistics service quality scale. Journal of Business Logistics 20, 9 (1999)
87. ADR - European Agreement Concerning the International Carriage of Dangerous Goods by Road. Applicable as from 1 January 2013. United Nations, New York [etc.] (2012)
88. Regulation on the harmonisation of certain social legislation relating to road transport. (2006)
89. McGuinnes, D. and van Harmelen, F.: OWL 2 Web Ontology Language Document Overview (Second Edition). W3C Recommendation 11 December 2012, https://www.w3.org/TR/owl2-overview/
90. Baader, F.: The description logic handbook. Theory, implemention, and applications. Cambridge Univ. Press, Cambridge [u.a.] (2004)
91. Hohpe, G., Woolf, B.: Enterprise integration patterns. Designing, building and deploying messaging solutions. Addison-Wesley, Boston (2015)
92. Rai, A., Pavlou, P.A., Im, G., Du, S.: Interfirm IT Capability Profiles and Communications for Cocreating Relational Value: Evidence from the Logistics Industry. MIS Quarterly 36, 233–262 (2012)
93. Marucheck, A., Greis, N., Mena, C., Cai, L.: Product safety and security in the global supply chain: Issues, challenges and research opportunities. Journal of Operations Management 29, 707–720 (2011)
94. Zhou, M., Zhang, R., Xie, W., Qian, W., Zhou, A.: Security and Privacy in Cloud Computing: A Survey. In: 2010 Sixth International Conference on Semantics Knowledge and Grid (SKG), pp. 105–112 (2010)
95. Schwarzbach, B., Glöckner, M., Schier, A., Robak, M., Franczyk, B.: User specific privacy policies for collaborative BPaaS on the example of logistics. In: 2016 Federated Conference on Computer Science and Information Systems, pp. 1205–1213. IEEE (2016)
96. Madkour, M., Driss, E.-G., Hasbi, A.: Context-aware service retrieval in uncertain context. In: 2012 International Conference on Multimedia Computing and Systems (ICMCS), pp. 611–616
97. Czyszczoń, A., Zgrzywa, A.: Review of Current Web Service Retrieval Methods. In: Król, D., Madeyski, L., Nguyen, N.T. (eds.) Recent Developments in Intelligent Information and Database Systems, 642, pp. 173–182. Springer International Publishing, Cham (2016)
98. Arnold, U., Oberlander, J., Schwarzbach, B.: LOGICAL—Development of cloud computing platforms and tools for logistics hubs and communities. In: Computer Science and Information Systems (FedCSIS), 2012 Federated Conference on, pp. 1083–1090 (2012)
99. Cardoso, J.: Modeling Service Relationships for Service Networks. In: van der Aalst, W., Mylopoulos, J., Rosemann, M., Shaw, M.J., Szyperski, C., Falcão e Cunha, J., Snene, M., Nóvoa, H. (eds.) Exploring Services Science, 143, pp. 114–128. Springer Berlin Heidelberg, Berlin, Heidelberg (2013)

100. Erradi, A., Kulkarni, N., Maheshwari, P.: Service Design Process for Reusable Services: Financial Services Case Study. In: Krämer, B.J., Lin, K.-J., Narasimhan, P. (eds.) Service-Oriented Computing – ICSOC 2007, 4749, pp. 606–617. Springer Berlin Heidelberg, Berlin, Heidelberg (2007)
101. Dörbecker, R., Böhmann, T.: Tackling the Granularity Problem in Service Modularization. In: Twenty-first Americas Conference in Information Systems (AMCIS) (2015)
102. Selviaridis, K., Spring, M.: The dynamics of business service exchanges. Insights from logistics outsourcing. Journal of Purchasing and Supply Management 16, 171–184 (2010)
103. Karagiannis, D., Kühn, H.: Metamodelling Platforms. In: Goos, G., Hartmanis, J., van Leeuwen, J., Bauknecht, K., Tjoa, A.M., Quirchmayr, G. (eds.) E-Commerce and Web Technologies, 2455, p. 182. Springer Berlin Heidelberg, Berlin, Heidelberg (2002)
104. Braun, C., Winter, R.: A comprehensive enterprise architecture metamodel and its implementation using a metamodeling platform (2005)
105. Wiliam, D., Black, P.: Meanings and Consequences. A basis for distinguishing formative and summative functions of assessment? British Educational Research Journal 22, 537–548 (1996)
106. Klecun, E., Cornford, T.: A critical approach to evaluation. Eur J Inf Syst 14, 229–243 (2005)
107. Sun, Y., Kantor, P.B.: Cross-Evaluation. A new model for information system evaluation. J. Am. Soc. Inf. Sci. 57, 614–628 (2006)
108. Gummesson, E.: Qualitative methods in management research. Sage, Thousand Oaks, Calif. (2000)
109. Mathiassen, L.: Object-oriented analysis & design. Marko, Aalborg, Denmark (2000)
110. Smithson, S., Hirschheim, R.: Analysing information systems evaluation. Another look at an old problem. Eur J Inf Syst 7, 158–174 (1998)
111. Budde, R., Kautz, K., Kuhlenkamp, K., Zullighoven, H.: Prototyping. An Approach to Evolutionary System Development. Springer Berlin Heidelberg, Berlin, Heidelberg (1992)
112. Object Management Group: Business Process Model and Notation (BPMN). Version 2.0, http://www.omg.org/spec/BPMN/2.0/PDF/

9.2 Executive Summary

The paper consolidates the formerly presented artifacts of the cloud logistics framework for engineering and management of cloud logistics services. Cloud principles are adopted to logistics and generic basic modules of (cloud) logistics services are created. A design science approach is used that focuses on the creation of IT artifacts. Based on the framework of design oriented information systems research [Österle, Becker, et al., 2011], several methods, i.e. [Newell, Herbert Alexander Simon, et al., 1972; Wickelgren, 1974; Vom Brocke, Simons, Riemer, et al., 2015; Smith, 1988; Herbert A. Simon et al., 1981; Goel, 1997; Rowe, 1991; Smith, 1992; Hara et al., 2009; Czarnecki and Eisenecker, 2000; Ritchey, 2013; Atkinson and Kühne, 2003; Briggs et al., 2011; Venable et al., 2014; Peffers, Rothenberger, et al., 2012], are involved to analyze, design, and evaluate the artifacts. The paper answers the research question *"How should a logistics service system be designed as to adopt cloud principles?"*

The paper presents a comprehensive conceptual elaboration of the cloud logistics paradigm: next to the definition of 'cloud logistics', the foundational artifacts for the engineering of generic modular cloud logistics services as well as for the management of those services are presented. Finally, the prototypical implementation is presented, see Figure 9.1. The initial set of artifacts has been consolidated, creating a starting point for future research on cloud logistics and digitalized supply chains. An XML-based description is defined and the concept of reusable building blocks is invoked. In Addition to the first definition of cloud logistics, the conceptual framework of cloud computing is extended by a domain-specific dimension and the layers of resources, capabilities and objects in order to describe the field of cloud logistics.

Evaluation.xml


```xml
<?xml version="1.0" encoding="UTF-8"?>
<bpmn2:definitions xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:bpmn2="http://www.omg.org/spec/BPMN/20100524/MODEL" xmlns:bpmn
  <bpmn2:process id="Process_1" isExecutable="false">
    <bpmn2:startEvent id="StartEvent_1">
      <bpmn2:outgoing>SequenceFlow_1tb4927</bpmn2:outgoing>
      <bpmn2:outgoing>SequenceFlow_0kr59uj</bpmn2:outgoing>
    </bpmn2:startEvent>
    <bpmn2:task id="service147646040306957d1d3b810fc9a801899b209" name="Warehousing">
      <bpmn2:incoming>SequenceFlow_1tb4927</bpmn2:incoming>
      <bpmn2:outgoing>SequenceFlow_1opqtyh</bpmn2:outgoing>
    </bpmn2:task>
    <bpmn2:task id="service147646041093757d1ce3c10fc9a801899b1fb" name="Inventory Management">
      <bpmn2:incoming>SequenceFlow_026skqt</bpmn2:incoming>
    </bpmn2:task>
    <bpmn2:task id="service147646041276957d1cd0010fc9a801899b1f7" name="Picking">
      <bpmn2:incoming>SequenceFlow_0kr59uj</bpmn2:incoming>
      <bpmn2:outgoing>SequenceFlow_026skqt</bpmn2:outgoing>
    </bpmn2:task>
    <bpmn2:task id="service147646041875657d1d0ef10fc9a801899b200" name="Transportation">
      <bpmn2:incoming>SequenceFlow_1opqtyh</bpmn2:incoming>
    </bpmn2:task>
    <bpmn2:sequenceFlow id="SequenceFlow_1tb4927" sourceRef="StartEvent_1" targetRef="service147646040306957d1d3b810fc9a801899b209" />
    <bpmn2:sequenceFlow id="SequenceFlow_1opqtyh" sourceRef="service147646040306957d1d3b810fc9a801899b209" targetRef="service147646041875657d1
    <bpmn2:sequenceFlow id="SequenceFlow_026skqt" sourceRef="service147646041276957d1cd0010fc9a801899b1f7" targetRef="service147646041093757d1
    <bpmn2:sequenceFlow id="SequenceFlow_0kr59uj" sourceRef="StartEvent_1" targetRef="service147646041276957d1cd0010fc9a801899b1f7" />
  </bpmn2:process>
  <bpmndi:BPMNDiagram id="BPMNDiagram_1">
    <bpmndi:BPMNPlane id="BPMNPlane_1" bpmnElement="Process_1">
      <bpmndi:BPMNShape id="_BPMNShape_StartEvent_2" bpmnElement="StartEvent_1">
        <dc:Bounds x="200" y="240" width="36" height="36" />
      </bpmndi:BPMNShape>
      <bpmndi:BPMNShape id="Task_1laaljw_di" bpmnElement="service147646040306957d1d3b810fc9a801899b209">
        <dc:Bounds x="400.6" y="122" width="100" height="80" />
      </bpmndi:BPMNShape>
```


Figure 9.1: XML code snippet of a complex service consisting of modular basic logistics services.

In terms of contribution type level (see Table 1.2) and the kind of knowledge contribution (see Table 1.9), the artifacts of the paper can be characterized as follows: The comprehensive consolidation of elementary artifacts within the framework can be considered design theory about an embedded phenomena, thus the artifact can be located on the third level of research contribution types. In addition, with the first presentation of a comprehensive new solution to the new problem of cloud logistics, the artifact constitutes an invention.

This papers comprises the consolidation for the engineering and management of cloud logistics services (i.e. "service landscape" and "service map") and is built upon the artifacts of paper #1 - #6.

10 Conclusion and Future Work

The final chapter summarizes the included papers with their inherent contributing artifacts, concludes the thesis, and discusses the findings. The results are critically appraised, and an outlook on future research directions is given.

10.1 Developed Artifacts

The cumulative thesis comprises the following eight contributions that answer the research questions of section 1.2 and have been developed, described and published within the former included papers:

1. Conceptual basis of the cloud logistics service landscape that facilitates the engineering [Glöckner et al., 2017], see Chapter 2.

   With the help of a systematic literature review, the field of cloud logistics is analyzed, conceptualized and a first definition of the term cloud logistics in scientific literature is given. The conceptual framework of cloud computing is extended by a domain-specific dimension and the layers of resources, capabilities and objects in order to describe the field of cloud logistics. Further, cloud logistics service blueprints are developed as a conceptual template for the creation of logistics services in cloud logistics. This paper lays the foundation for the engineering of cloud logistics service description and is complemented technically by the artifact of paper #2. The insights are further used for the service granularity framework (#5), transitively for the prototype (#6), as well as the consolidation and research roadmap (#8).

2. Technical basis of the cloud logistics service landscape that facilitates the engineering [Glöckner and Ludwig, 2017a], see Chapter 3.

   The NeOn methodology is used to develop an ODP that describes logistics services semantically and thus enables a bridging of the syntactic differences between heterogeneous LSP. Data and information (of services) from different providers can be made available, linked and interchanged easily within supply chains. Virtualized resources and digitalized collaboration are supported. This paper lays the foundation for the engineering of cloud logistics service description and technically complements paper #1. The insights are further used for the service granularity framework (#5), transitively for the prototype (#6), as well as the consolidation and research roadmap (#8).

3. Conceptual basis of the cloud logistics service map that facilitates the management [Glöckner, Augenstein, et al., 2014], see Chapter 4.

   A metamodeling approach is utilized to create a conceptual model of the logistics service map. This artifact enables the systematic categorization within a catalog in order to facilitate retrieval and management of logistics services. This paper lays the foundation for the management of cloud logistics services and is technically complemented by the artifact of paper #4. The insights are further used for the service granularity framework (#5), transitively for the prototype (#6), as well as the consolidation and research roadmap (#8). This artifact is applied within a compound approach for tactical logistics planning in paper #7.

4. Technical basis of the cloud logistics service map that facilitates the management [Glöckner and Ludwig, 2017c], see Chapter 5.

   The NeOn methodology is used to develop an ODP that semantically describes and consolidates essential common structuring approaches of the logistics domain for logistics services. Thus, it enables a bridging of the syntactic differences between heterogeneous LSP and their structuring approaches of logistics services. The essential structuring concepts of the logistics domain are distilled into one ODP. Hence, the structuring can easily be mapped and an ontological connection (with `owl:sameAs`) between similar concepts of different LSP can be set up and the semantic gap is closed. This paper lays the foundation for the management of cloud logistics service description and technically complements paper #3. The insights are further used for the service granularity framework (#5), transitively for the prototype (#6), as well as the consolidation and research roadmap (#8).

5. Service granularity framework that facilitates both the engineering and management of cloud logistics services [Glöckner et al., 2016b], see Chapter 6.

   A systematic literature review is conducted in order to find existing concepts of service granularity. Findings are analyzed and eventually synthesized towards their suitability of forming a comprehensive conceptual service granularity framework. Different kinds of service granularity (i.e. horizontal and vertical granularity) are defined. Further, conceptual levels for handling service granularity within specific units of organization (i.e. provider levels) and between specific units of organization (i.e. common mapping level) are defined. Thus, a common understanding of different granularity levels between heterogeneous participants can be established. As a proof of concept, the framework is applied to the logistics domain in order to enable modular logistics services. This paper is the foundation for a conceptualization of service granularity. The insights are used for the prototype (#6), as well as the consolidation and research roadmap (#8).

6. Prototype of the logistics service map as a proof of concept [Glöckner, Niehoff, et al., 2017], see Chapter 7.

   A technical proof of concept is realized via prototyping the logistics service map concept within a single page web application. The prototype is implemented in the free and open-source JavaScript software stack 'MEAN' consisting of mongoDB, express, angularJS, and node.js. This software prototype proves the cloud-environment applicability and thus distributed usage, and scalability. The prototype could be used for further acceptance improvement. This paper provides a technical proof of concept, by implementing a prototype, based on the findings of papers #1 - #5. The insights are used for the consolidation and research roadmap (#8).

7. Application in the context of tactical logistics planning within a systematic approach for integrated engineering and evaluation of process alternatives [Glöckner, Mutke, Augenstein, et al., 2015], see Chapter 8.

   Method engineering is used to create an integrated approach of (semi-)automatic engineering of process alternatives with the help of the systematic categorization approach of the logistics service map. Those process alternatives could then be evaluated using different simulation frameworks. This example application provides a perspective on how the developed artifacts could be used in a logistics network context. This paper provides an example for the application of the service map concept, based on the artifact of papers #3.

8. Consolidation of the main artifacts and integration to a basic set for cloud logistics [Glöckner and Ludwig, 2019] (publication ready), see Chapter 9.

   Based on the design oriented information systems research framework, the former artifacts are integrated. The resulting cloud logistics approach is associated with the current trend of digitalization in supply chains and the emerging IoT paradigm. Further, the overall approach is justified and evaluated. This paper consolidates the former artifacts (papers #1 - #6) and outlines their interaction and synergy in order to enable the paradigm of cloud logistics, and thus a cooperation of LSP in a digitalized context of future supply chains.

10.2 Summary

The thesis focuses on the development of foundational research artifacts for virtualizing, categorizing and encapsulating resources and services of logistics within reusable modules. This framework is denoted as the *Cloud Logistics* paradigm and constitutes a rather young field of research with a high potential for the collaboration and coopetition of LSPs in digitized logistics industry and supply chains. The thesis contains a basic set of conceptual and technical artifacts to enable this paradigm. The presented artifacts support the cloud logistics' business model of the logistics integrator (LI) in aligning physical and non-physical resources of heterogeneous logistics service providers (LSP) within compatible encapsulations. The generic and extensible standard for the *engineering* and *management* of cloud logistics services is built upon the semantic approach of ontology design patterns (ODP) in order to bridge the semantic gap in the heterogeneous business environment of logistics. Figure 10.1 shows the resulting approach towards cloud logistics with the allocation of the developed artifacts.

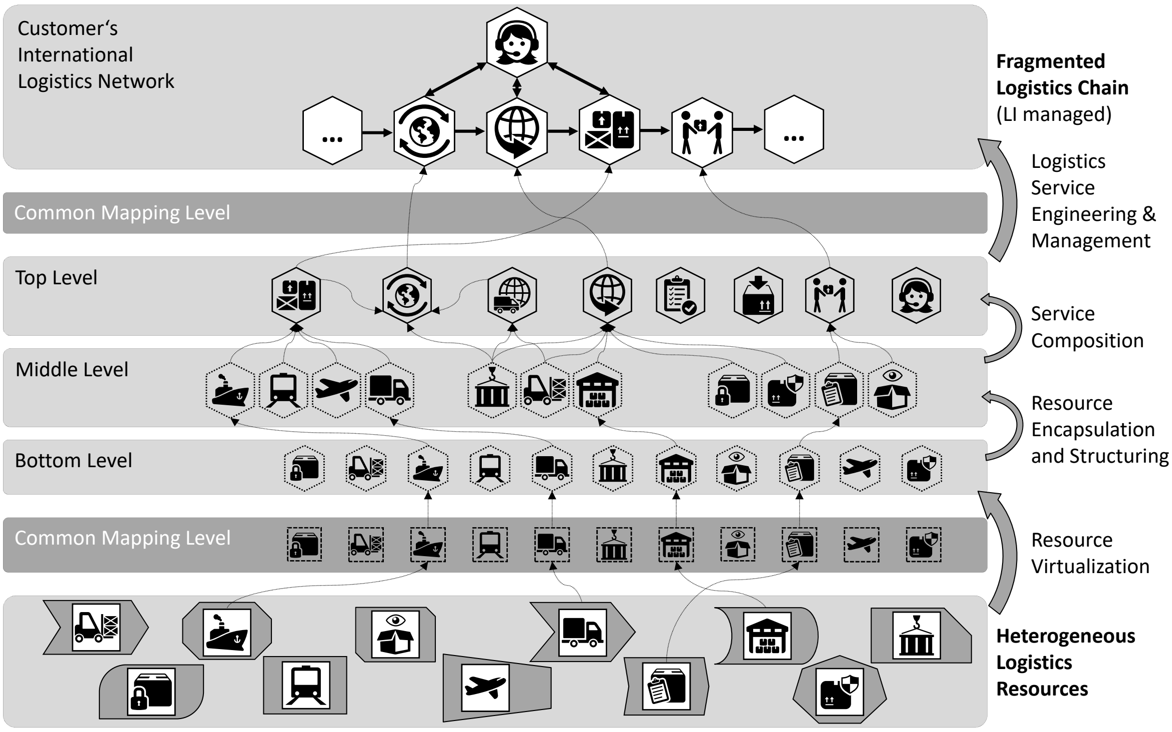

Figure 10.1: Consolidation of the developed artifacts and allocation within the framework of cloud logistics. Icons made by Freepik from www.flaticon.com.

The relationship of the artifacts is described with the help of the Figure 10.1 going bottom-up. On the lowest level, the LSPs and their heterogeneous resources are allocated. The heterogeneity is displayed via different shapes, each containing a certain logistics capability (according to the framework of CL, see Figure 2.1 in chapter 2). From a granularity perspective, those are the resources and services offered by the LSP to potential customers, hence they are located on the top level of the LSPs' provider levels (according to the granularity conceptualization, see in chapter 6). Via the (darker) Common Mapping Level (see granularity conceptualization as well), which contains the canonical schema and the service meta data (i.e. service blueprints for cloud logistics services (see description in chapter 2) and the semantic approach of the LoSe ODP, see Figure 3.1 in chapter 3), the capabilities of logistics resources and services are extracted, and virtually allocated on the bottom level of the LI's provider levels. The extracted capabilities are collected within the service map as atomic services by expressing them with the existing service templates (see prototype in chapter 7) that are based on the logistics service blueprints (chapter 2) and the LoSe ODP, see Figure 3.1 in chapter 3. Hence their syntactical differences can be semantically bridged via the semantic approach of the ODP, and they can be encapsulated within reusable cloud logistics services. By linkage (via the LoSeMa ODP, see chapter 5) to a certain template and the integration of (1) LSPs' information on the services, and (2) the structuring elaborated by the LI, those services are can be structured and clustered within different fields of a matrix in the prototype according to selected dimensions (Middle Level), and represented to the logistics or supply chain planer using the service map (see chapter 4 and chapter 5). In Figure 10.1, the clustering is done via the classification of (from left to right) (1) means of transportation, (2) handling and warehousing, and (3) picking and packing. The planner can drag'n'drop atomic services from different clusters onto a BPMN-canvas in order to create more complex composite logistics services. Within the prototype, it is possible to save the resulting complex services in a BPMN file (XML-based) and as a graph at the same time. Those BPMN files can be used to integrate further customer specific data, run process engines, and automate workflows. Summarizing, with this approach the created complex services can contain resources from different heterogeneous LSPs and be operated (semi-)automatically.

In Figure 10.1, the complex services on the LI's top level are connected to each other in order to perform a customer's *International Logistics Network*. First, global transport is conducted with different means of transport and the interchange of goods between different means of transport. Second, transshipment and customs are done in a port of the final destination country. Third, the hinterland transport is done with further means of transport towards the final destination. Fourth, inbound logistics processes at a certain production facility are forming the end of the LI-managed logistics chain.

Summarizing, Ontology Design Pattern (ODP) are a semantic approach to bridge the syntactic gap between differing wordings, descriptions, and IT systems of heterogeneous LSP. The approach of the ODP [Gangemi, 2005] is used to facilitate ontology engineering by creating reusable artifacts with varying purposes [Gangemi, Gómez-Pérez, et al., 2007]. The advantage of ODP [Gangemi, 2005] is that ontology engineers can then draw on those patterns to reduce time and mistakes during the ontology creation process. Additionally, design and communication is easier for both knowledge engineers and domain experts. ODP have been proven [Blomqvist et al., 2009] to be perceived as useful, improving the ontology quality, increasing the task coverage, enhancing usability, and in avoiding common modeling mistakes. Their main objective is ontology integration. Hence, the semantic description of logistics services offers the possibility of integrating data and knowledge from different LSP in order to enable CL. The technical artifacts (#2 & #4) provide a first point to customize own semantic schema of logistics services modules engineering (landscape) and management (map) for the LI in the context of cloud logistics. The common semantic ODPs for all logistics services enable compatibility of modular logistics services that are based on that common foundation. An important advantage of semantic web techniques for bridging the gap between differing concepts, syntax and vocabulary [Hitzler et al., 2010] of different LSP [Preist et al., 2005], is the combined possibility of *knowledge representation* and *reasoning* [Hitzler et al., 2010]. Thus, logistics is turned into an open and collaborative space.

10.3 Implications

In accordance with the framework on design science in information systems research [Hevner et al., 2004], rigor and relevance are important aspects. *Rigor* is granted by the application of approved scientific methods and their linkage via the framework formulated in the memorandum on design-oriented information systems research [Österle, Becker, et al., 2011] and the resulting artifacts and implications that enrich the scientific knowledge base. *Relevance* on the other hand is granted by the reference and connection to the logistics domain that acts as the source of problem and validation and that benefit from the resulting artifacts and implications in a practical way.

The study of Wieland et al. [2016] amongst SCM researchers showed a strong need for interdisciplinary thoughts and rigor approaches in order to tackle future supply chain challenges such as sustainability, complexity and digital integration. Further, researchers are encouraged *"to jump into the void of new problems with little developed theoretical bases"* by the study of Wieland et al. [2016]. The research on *Cloud Logistics* still is a young research field with very little theoretical and practical base [Delfmann and Jaekel, 2012; Glöckner et al., 2017] but high potentials for future logistics and supply chains (see 1.1). Hence, this thesis can be recognized as a pioneering piece of work in the field of Cloud Logistics, providing starting points for researchers and practitioners.

Scientific Implications

Implications for CL as a research discipline and for the involved researchers comprise mainly an initial set of design-oriented artifacts as a framework to enable this paradigm and to further explore possible potentials. Within those contributions to the scientific knowledge base, some artifacts are to be highlighted:

- first scientific definition of *Cloud Logistics* [Glöckner et al., 2017]
- progression of the conceptual *framework of CL* [Glöckner et al., 2017]
- first conceptualization of *service granularity* and definition of several granularity aspects and distinct conceptual granularity levels [Glöckner et al., 2016b]

- first *logistics domain related content ODP* are developed and added to the ODP community[1] [Glöckner and Ludwig, 2017a; Glöckner and Ludwig, 2017b]

Practical Implications

As the results mark an initial set of artifacts for the foundation of CL, the thesis contributes to the following outlined practical implications of CL.

In particular, different LSP can be integrated faster and more flexibly with the help of the semantic approach [Preist et al., 2005], which facilitates planning and rescheduling activities in cases of uncertainties [Stevenson and Spring, 2007]. Further, implicit knowledge can be derived by reasoning [Hitzler et al., 2010]. Ontologies are an appropriate way of managing and representing knowledge, making it accessible and understandable to both human beings and machines. They enable the formal naming and definition of objects, properties, and their interrelations [Hitzler et al., 2010; Gangemi and Presutti, 2009].

In general, practitioners benefit from the inherent paradigm shift of CL that creates promising planning and coordination mechanisms for logistics and future supply chains. CL comprises a way of aligning physical and non-physical logistics resources from heterogeneous LSP via modular cloud logistics services. With the increasing importance of digital business strategies in general [Bharadwaj et al., 2013] and a steady need for effective IT solutions especially in logistics [Langley and Long, 2018; Langley and Long, 2017; Langley and Long, 2016] in order to integrate with shippers, customers, and coopetitors[2], CL marks an interesting option to meet this challenge. It could foster outsourcing of more knowledge intense (such as IT-related and strategic) logistics services that are still less likely to be outsourced than the more commodity-like ones [Langley and Long, 2018]. Thus, the LI as well as the LSPs are enabled by CL to focus more on their respective core competencies, such as either planning, IT integration, supply chain consulting or actual physical operation of logistics networks. In addition, the potential to rapidly assemble collaborative logistics networks in order to efficiently and effectively execute international trading activities (see e.g. [Langley and Long, 2018; Metzger et al., 2012; Fuchs and Otto, 2015; Rai et al., 2012; Wilding and Juriado, 2004]), could be drawn from the emerging paradigm of CL. Moreover, flexible on-demand scalability of modular logistics services [Kückelhaus et al., 2016] is another potential benefit. Finally, potential benefits result from improved handling of integration, higher transparency and visibility, facilitated coopetition, and better handling of complexity, and volatility. Those issues are emphasized by the study of Wieland et al. [2016] as important challenges for future SCM research landscape. In a nutshell, collaboration of heterogeneous LSP is facilitated.

[1] http://ontologydesignpatterns.org/wiki/Submissions:ContentOPs

[2] The term coopetitor is stems from from "coopetition" which is a conflation of cooperation and competition.

10.4 Limitations and Threats to Validity

The presented set of contributions constitutes an initial conceptual step of artifacts dedicated to the relatively young research field of cloud logistics. This leads to special conditions, especially following a design science research approach. Hence, limitations are to be discussed.

First, the developed artifacts focus on a certain understanding of logistics in the context of tactical planning in meta logistics, i.e. collaborating LSP. This characteristic induces a certain threat in the artifacts' generalizability. As meta logistics is constituted a part of macro logistics, a generalization to macro logistics is conceivable. In terms of micro logistics, e.g. intra-logistics or production logistics, it has to be proven whether results are adaptable.

Second, concepts are mainly derived from existing literature and theory. This deductive approach further implies a lack in practical substantiation for the majority of the artifacts.

Third, the focus and completeness of scientific publications and empirical sources analyzed can be considered neither comprehensive nor exhaustive. Publications may have been left out because of the applied database selection criteria. Technical limitations of the utilized search engines are to be mentioned that can not be estimated nor influenced by the author. Further, mostly journal-focused databases were taken into account as conference proceedings at times have the tendency to be seen as of lower quality [Levy and Ellis, 2006]. On the contrary, the literature review in [Glöckner et al., 2017], for instance, has shown a higher hit ratio in the 'SpringerLink' database, which is rather mixed in terms of journal and conference proceeding. Hence, further research could be expanded to more conference-focused databases. In this context it is important to mention new directions of thought concerning literature reviews: Vom Brocke, Simons, Riemer, et al. [2015] outline a rather pragmatic view on the need for 'comprehensive' literature reviews. In the current times of ever increasing amount of literature published and available, papers inevitably have to be omitted due to sheer amount and ever increasing production and publication rate. Depending on the range of a topic, it could be impossible to even read all existing publications in a reasonable range of time[3]. One solution could be the refinement of focus and the change of strategy in favor of rather thoroughly analyzing seminal work in combination with forward and backward search than striving for comprehensiveness and having *all* literature, even those papers without meaningful impact, included in the literature review [Vom Brocke, Simons, Riemer, et al., 2015]. Hence, quality of a systematic literature is becoming more important than the pure quantity of publications analyzed.

Fourth, a residual threat remains the reliability of results. Evaluation and interpretation of analyzed literature was conducted to the best of the authors knowledge and

[3] Searching Google Scholar for publications since 2014 brings about 924.000 results for 'big data' and 52.200 results for the term 'iot architecture'. (as looked up 12.12.2018)

backed by external feedback. However, analysis and synthesis of the concepts and development of the artifacts are based on the opinion of the researching author (human being), and thus are not beyond bias. Hevner et al. [2004] for instance argue that, especially in emerging research topics, the artifact itself can be seen as an experiment. Nevertheless, by making the utilized research methods and their limitations explicit throughout the thesis, traceability and transparency are fostered.

Fifth, the evaluation of the total result of the thesis is not comprehensive nor thoroughly done in terms of empirical sufficient extent. On the one hand, this results from the cumulative character with the inherent evaluation focus in the several papers on each respective contained artifact. On the other hand, Gregor and Hevner [2013] explicate that, next to the aspect that artifacts of emerging fields are experiments themselves [Hevner et al., 2004], a certain degree of flexibility shall be allowed when judging the degree of evaluation for new design science research contributions. Especially for very novel artifacts, a *proof-of-concept* may be sufficient [Gregor and Hevner, 2013]. This is justified with the effort of developing artifacts with inherent formative testing. Hence, summative (final) testing as a comprehensive evaluation should not be necessarily expected as thoroughly as in behavioral research projects that focus on already existing artifacts. In addition, the review process of scientific conferences and journals is explicitly denoted as being already part of the evaluation process by Österle, Becker, et al. [2011]. As all basic artifacts are published in double-blind review based scientific venues, they can be also seen as evaluated.

10.5 Outlook and Subsequent Research Perspectives

With the characteristics of being foundational research artifacts and thus an initial set of solution approaches in the field of cloud logistics, the results and the former outlined limitations imply a certain number of aspects for further research. The future research perspectives are related to scientific aspects as well as to the three categories of human, business, and technology aspects. Hence, an interdisciplinary view on (cloud) logistics and the adjacent scientific fields is a crucial issue for future research activities.

Scientific Related Aspects

With regards to research related aspects, a broader range of the analyzed scientific sources, such as databases with a focus on conference proceedings, could improve the artifacts. Further, extended empirical studies on the topic and insights from practical implementation and usage will lead to new insights and further development. In addition, prior or within those empirical studies, a further evaluation, based on the FEDS [Venable et al., 2014] appears to be reasonable. New insights and feedback for the conceptual framework and the prototype could be generated with a refinement and a higher number of real life logistics services being represented, described and connected by the prototype. Hence, embedding those cloud logistics services within a digitalized logistics network would lead to further insights and improvements. In addition, the allocation and distinction of the interdisciplinary research topic CL in both related fields of *logistics research* and *information systems research* are important future task in order to develop it towards a fully accepted interdisciplinary scientific research stream. A first attempt for this purpose was made by Jaekel [2019].

Human Related Aspects

The human related research aspects for future efforts can be summarized under the term user acceptance, which is indeed an important field in general as highlighted by many SCM researchers in the study of Wieland et al. [2016]. They outline future research potentials for SCM in terms of integrating data from all parts of supply chain within a dashboard, they emphasize an advanced visualization for generating new insights, and a reduction of complexity for easier decision making. With the developed prototype, a first step is made into the described direction, but still potential exists for further usability improvement. On the other hand, trust and privacy are important aspects to be granted in order to increase user acceptance. Dealing with existing resistance: it is important to convince LSP to share certain data that are important for an integrative supply chain and digital coopetition. Collaboration becomes more and more essential for LSP in order to remain competitive and to basically survive on the market, hence a shift in perceiving and living the relationship to competitors on the market becomes compulsory. Hence, a crucial challenge is to find methods and evaluation scenarios that prove the benefits of collaboration in cloud logistics and digitalized supply chains. It is important to demonstrate that the benefits outweigh the partly digital release of confidential data (such as capacities, prices of LSPs' infrastructure and asset usage) that have to be shared anyway when working with business partners. A drilling down into trust related issues is important to convince the most important factor, eventually deciding on the implementation of digitalized approaches such as cloud logistics: human factor and decision makers of SCM. First promising approaches of attribute-based privacy preserving approaches can be found, e.g. in [Schwarzbach, Glöckner, Franczyk, et al., 2017; Schwarzbach, Glöckner, Schier, et al., 2016].

Business Related Aspects

Future business related research aspects relate to several issues. On the one hand, with a more general view, the engineering of a suitable business model of an 'cloud operator' for Logistics [Delfmann and Jaekel, 2012] based on the LI concept but with higher IT competence on implementing the CL framework appears to be useful in order to foster the cloud logistics paradigm. On the other hand, to advance the inner functionality of cloud logistics, approaches such as service profiles [Roth et al., 2014] or comprehensive planning environments for logistics contracts [Mutke et al., 2015] and their integration in CL, could further amplify the benefits. Eventually, as described before, empirical findings from further evaluation when implementing the cloud logistics framework with a higher number of real life logistics services in a more complex network will lead to new insights on business related topics within the CL framework.

Technology Related Aspects

Research concerning technological aspects mainly focuses on integration. An important research issue is the collection of data and information for the creation of the services within the service map. Currently, registration of logistics services to the catalog of the map has to be done manually. Research and development work concerning this topic comprises two issues. First, the technical integration with systems of the involved LSP is an important issue - not only for the recognition of data concerning the creation of new services but also for the later collaboration and data exchange in the actual operation of (cloud) logistics networks and supply chains. One possible direction could be the prototype extension with integration of IT systems following the approach of [Klinkmüller et al., 2011]. Second, the extraction and analysis of existing data from the involved LSP as well as the data processing are interesting research issues. This comprises aspects such as text and pattern recognition in unstructured data like textual process descriptions, their matching to either existing service templates or the creation of new templates in case of completely new service types.

Further, the improvement of interaction between the semantic description of basic services in the context of the OWL-based (i.e. XML-based) ODP and the process oriented description of complex services for the operation with the (as well) XML-based BPMN standard shows potential for improvement. In literature, several approaches are already described that could be integrated into the prototype, e.g. basic Input-Output-Precondition-Effect (IOPE) models [Hoxha et al., 2010], or transformation of XML to OWL and vice versa [Sakka et al., 2011]. Others can be found in accordance with Scheuermann and Joerg Leukel [2014] in the approach of complementing the specification with rules that process the ontology instances [Lu et al., 2013; Chi, 2010]. Fully integration of artifacts in terms of syntactic transformation between XML Schema of the Prototype and OWL can be reached by syntactic translators that are developed by using Extensible Stylesheet Language Transformation (XSLT). This rule-based approach could map semantically similar terminologies between existing ontologies, such as the developed ODP and the derived services (templates) on the one hand, and application ontologies of the LSP on the other hand with the aim of enabling semantic interoperability among applications in supply chains [Ye et al., 2008]. Another approach would be the use of semantically annotated Web Service Description Language (WSDL) with pointers to concepts defined in ontologies [Das et al., 2015].

Eventually, one crucial challenge remains: the hardware side in order to enable cloud logistics. As Kückelhaus et al. [2016] summarize, the physical assets need to be ready in terms of smart infrastructures that allow for decentralized control, flexibility, and data exchange. With this on hand, cloud logistics is also an interesting topic to combine with approaches such as, e.g. Internet of Things (IoT) [Miorandi et al., 2012], physical internet [Montreuil et al., 2013], or digital twin [Schleich et al., 2017; Boschert and Rosen, 2016]. Cloud logistics could serve as a source of virtualized modular logistics resources, which are virtually encapsulated within modular building blocks, for those approaches in order to provide them as a foundation for the context of logistics in general and to digitally work in complex environments of collaborating heterogeneous LSP in particular.

In conclusion, the developed artifacts help to establish first starting points in the field of cloud logistics for future research activities in this rather young area of research. Especially, the virtualized and encapsulated modular logistics resources and resulting cloud logistics services hold enormous potential to bridge the heterogeneity of collaborating and coopetiting LSP and to provide a domain-specific foundation for other emerging technologies and paradigms, such as IoT, physical internet or digital twins, by turning logistics into an open and collaborative space. The current thesis strives to provide a basis and inspiration for this development that has only just begun.

Bibliography

[Agarwal and Lucas 2005]Agarwal, Ritu and Henry C. Lucas JR. (2005). “The information systems identity crisis: Focusing on high-visibility and high-impact research”. In: *MIS Quarterly*, pp. 381–398.

[Archer 2006]Archer, Norman P. (2006). “Supply chains and the enterprise”. In: *Journal of Enterprise Information Management* 19.3, pp. 241–245. ISSN: 1741-0398. DOI: 10.1108/17410390610658432.

[Arnold et al. 2008]“Logistikdienstleistungen” (2008). In: *Handbuch Logistik*. Ed. by Dieter Arnold, Heinz Isermann, Axel Kuhn, Horst Tempelmeier, and Kai Furmans. VDI-Buch. Berlin, Heidelberg: Springer Berlin Heidelberg, pp. 581–607. ISBN: 978-3-540-72928-0. DOI: 10.1007/978-3-540-72929-7{_}13.

[Atkinson and Kühne 2003]Atkinson, C. and T. Kühne (2003). “Model-driven development: A metamodeling foundation”. In: *IEEE Software* 20.5, pp. 36–41. ISSN: 0740-7459. DOI: 10.1109/MS.2003.1231149.

[Audy et al. 2012]Audy, Jean-François, Nadia Lehoux, Sophie D’Amours, and Mikael Rönnqvist (2012). “A framework for an efficient implementation of logistics collaborations”. In: *International Transactions in Operational Research* 19.5, pp. 633–657. ISSN: 09696016. DOI: 10.1111/j.1475-3995.2010.00799.x.

[Baines et al. 2007]Baines, T. S. et al. (2007). “State-of-the-art in product-service systems”. In: *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture* 221.10, pp. 1543–1552. ISSN: 0954-4054. DOI: 10.1243/09544054JEM858.

[Barquet et al. 2016]Barquet, Ana Paula, Johannes Seidel, Tom Buchert, Mila Galeitzke, Sabrina Neugebauer, Nicole Oertwig, Henrique Rozenfeld, and Günther Seliger (2016). “Sustainable Product Service Systems – From Concept Creation to the Detailing of a Business Model for a Bicycle Sharing System in Berlin”. In: *Procedia CIRP* 40, pp. 524–529. ISSN: 22128271. DOI: 10.1016/j.procir.2016.01.127.

[Bask et al. 2010]Bask, Anu, Mervi Lipponen, Mervi Rajahonka, and Markku Tinnilä (2010). “The concept of modularity: Diffusion from manufacturing to service production”. In: *Journal of Manufacturing Technology Management* 21.3, pp. 355–375. ISSN: 1741-038X. DOI: 10.1108/17410381011024331.

[Baumgarten 2008]Baumgarten, Helmut (2008). *Das Beste der Logistik*. Berlin, Heidelberg: Springer Berlin Heidelberg. ISBN: 978-3-540-78404-3. DOI: 10.1007/978-3-540-78405-0.

[Beuren et al. 2013]Beuren, Fernanda Hänsch, Marcelo Gitirana Gomes Ferreira, and Paulo A. Cauchick Miguel (2013). "Product-service systems: A literature review on integrated products and services". In: *Journal of Cleaner Production* 47, pp. 222–231. ISSN: 09596526. DOI: 10.1016/j.jclepro.2012.12.028.

[Bharadwaj et al. 2013]Bharadwaj, Anandhi, Omar A. El Sawy, Paul A. Pavlou, and N. Venkatraman (2013). "Digital Business Strategy: Toward a next Generation of Insights". In: *MIS Quarterly* 37.2, pp. 471–482.

[Bibhushan et al. 2014]Bibhushan, Anuj Prakash, and Bharat Wadhwa (2014). "Supply Chain Flexibility: Some Perceptions". In: *The Flexible Enterprise*. Ed. by Sushil and Edward A. Stohr. New Delhi: Springer India, pp. 321–331. ISBN: 978-81-322-1559-2. DOI: 10.1007/978-81-322-1560-8{_}19.

[Blomqvist et al. 2009]Blomqvist, Eva, Aldo Gangemi, and Valentina Presutti (2009). "Experiments on pattern-based ontology design". In: *Proceedings of the fifth International Conference on Knowledge Capture (K-CAP '09)*. Ed. by Yolanda Gil and Natasha Noy, pp. 41–48. DOI: 10.1145/1597735.1597743.

[Boschert and Rosen 2016]Boschert, Stefan and Roland Rosen (2016). "Digital Twin—The Simulation Aspect". In: *Mechatronic Futures*. Ed. by Peter Hehenberger and David Bradley. Cham: Springer International Publishing, pp. 59–74. ISBN: 978-3-319-32154-7. DOI: 10.1007/978-3-319-32156-1{_}5.

[Brettel et al. 2014]Brettel, Malte, Niklas Friederichsen, Michael Keller, and Marius Rosenberg (2014). "How Virtualization, Decentralization and Network Building Change the Manufacturing Landscape: An Industry 4.0 Perspective". In: *International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering, volume = 8* 1, pp. 37–44. ISSN: PISSN:2010-376X, EISSN:2010-3778. URL: http://waset.org/Publications?p=85.

[Briggs et al. 2011]Briggs, Robert O., Jay F. Nunamaker, and Ralph Sprague (2011). "Special Section Applied Science Research in Information Systems: The Last Research Mile". In: *Journal of Management Information Systems* 28.1, pp. 13–16. ISSN: 0742-1222. DOI: 10.2753/MIS0742-1222280101.

[Brown 2012]Brown, Stephen (2012). "I have seen the future and it sucks: Reactionary reflections on reading, writing and research". In: *European Business Review* 24.1, pp. 5–19. ISSN: 0955-534X. DOI: 10.1108/09555341211191517.

[Buyya et al. 2009]Buyya, Rajkumar, Chee Shin Yeo, Srikumar Venugopal, James Broberg, and Ivona Brandic (2009). "Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility". In: *Future Generation Computer Systems* 25.6, pp. 599–616. ISSN: 0167739X. DOI: 10.1016/j.future.2008.12.001.

[Castano and Antonellis 1993]Castano, S. and V. de Antonellis (1993). “A constructive approach to reuse of conceptual components”. In: *[1993] Proceedings Advances in Software Reuse*. IEEE Comput. Soc. Press, pp. 19–28. ISBN: 0-8186-3130-9. DOI: 10.1109/ASR.1993.291721.

[Catteddu and Hogben 2009]Catteddu, Daniele and Giles Hogben (2009). *Cloud Computing: Benefits, risks and recommendations for information security*. Ed. by European Union. URL: https://www.enisa.europa.eu/publications/cloud-computing-risk-assessment/at_download/fullReport.

[Chapman and Ellinger 2009]Chapman, Karen and Alexander E. Ellinger (2009). “CONSTRUCTING IMPACT FACTORS TO MEASURE THE INFLUENCE OF SUPPLY CHAIN MANAGEMENT AND LOGISTICS JOURNALS”. In: *Journal of Business Logistics* 30.2, pp. 197–212. ISSN: 07353766. DOI: 10.1002/j.2158-1592.2009.tb00119.x.

[Chi 2010]Chi, Yu-Liang (2010). “Rule-based ontological knowledge base for monitoring partners across supply networks”. In: *Expert Systems with Applications* 37.2, pp. 1400–1407. ISSN: 09574174. DOI: 10.1016/j.eswa.2009.06.097.

[Choudhary and Vithayathil 2013]Choudhary, Vidyanand and Joseph Vithayathil (2013). “The Impact of Cloud Computing: Should the IT Department Be Organized as a Cost Center or a Profit Center?” In: *Journal of Management Information Systems* 30.2, pp. 67–100. ISSN: 0742-1222. DOI: 10.2753/MIS0742-1222300203.

[Christopher 2000]Christopher, Martin (2000). “The Agile Supply Chain”. In: *Industrial Marketing Management* 29.1, pp. 37–44. ISSN: 00198501. DOI: 10.1016/S0019-8501(99)00110-8.

[Clausen and Geiger 2013]Clausen, Uwe and Christiane Geiger (2013). *Verkehrs- und Transportlogistik*. Berlin, Heidelberg: Springer Berlin Heidelberg. ISBN: 978-3-540-34298-4. DOI: 10.1007/978-3-540-34299-1.

[Corsten and Felde 2005]Corsten, Daniel and Jan Felde (2005). “Exploring the performance effects of key–supplier collaboration”. In: *International Journal of Physical Distribution & Logistics Management* 35.6, pp. 445–461. ISSN: 0960-0035. DOI: 10.1108/09600030510611666.

[Czarnecki and Eisenecker 2000]Czarnecki, Krzysztof and Ulrich Eisenecker (2000). *Generative programming: Methods, tools, and applications*. Boston: Addison Wesley. ISBN: 0-201-30977-7.

[Das et al. 2015]Das, Moumita, Jack C.P. Cheng, and Kincho H. Law (2015). “An ontology-based web service framework for construction supply chain collaboration and management”. In: *Engineering, Construction and Architectural Management* 22.5, pp. 551–572. ISSN: 0969-9988. DOI: 10.1108/ECAM-07-2014-0089.

[Delfmann and Jaekel 2012]Delfmann, Werner and Falco Jaekel (2012). *The Cloud - Logistics for the Future? Discussionpaper*. Ed. by German Logistics Association - BVL International. URL: `http://www.bvl.de/misc/filePush.php?id=18910&name=Discussionpaper+Cloud+Logistis`.

[Downie 2016]Downie, Keith (2016). *Function as a Service, an Ad Hoc Approach to Cloud Computing*. Utah. URL: `https://pdfs.semanticscholar.org/92b2/fede99e0e88794b66ac27a3812505be7b730.pdf`.

[Duan, Cao, et al. 2015]Duan, Yucong, Yuan Cao, and Xiaobing Sun (2015). “Various “aaS” of everything as a service”. In: *2015 16th IEEE/ACIS International Conference on Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing (SNPD)*. Ed. by Keizo Saisho. Piscataway, NJ: IEEE, pp. 1–6. ISBN: 978-1-4799-8676-7. DOI: `10.1109/SNPD.2015.7176215`.

[Duan, Fu, et al. 2015]Duan, Yucong, Guohua Fu, Nianjun Zhou, Xiaobing Sun, Nanjangud C. Narendra, and Bo Hu (2015). “Everything as a Service (XaaS) on the Cloud: Origins, Current and Future Trends”. In: *2015 IEEE 8th International Conference on Cloud Computing (CLOUD)*, pp. 621–628. DOI: `10.1109/CLOUD.2015.88`.

[Embley and Thalheim 2011]Embley, David W. and Bernhard Thalheim (2011). *Handbook of Conceptual Modeling*. Berlin, Heidelberg: Springer Berlin Heidelberg. ISBN: 978-3-642-15864-3. DOI: `10.1007/978-3-642-15865-0`.

[Erl 2015]Erl, Thomas (2015). *Service-oriented Architecture: Concepts, Technology, and Design: Concepts, Technology, and Design*. Prentice Hall. ISBN: 978-0133858587.

[Esmaeilikia et al. 2014]Esmaeilikia, Masoud, Behnam Fahimnia, Joeseph Sarkis, Kannan Govindan, Arun Kumar, and John Mo (2014). “Tactical supply chain planning models with inherent flexibility: definition and review”. In: *Annals of Operations Research*.

[Fawcett et al. 2007]Fawcett, Stanley E., Paul Osterhaus, Gregory M. Magnan, James C. Brau, and Matthew W. McCarter (2007). “Information sharing and supply chain performance: The role of connectivity and willingness”. In: *Supply Chain Management: An International Journal* 12.5, pp. 358–368. ISSN: 1359-8546. DOI: `10.1108/13598540710776935`.

[Fowler 2013]Fowler, Floyd J. (2013). *Survey research methods*. Fifth edition. Applied social research methods series. Thousand Oaks: SAGE Publications, Inc. ISBN: 1483323595.

[Franke et al. 2016]Franke, Marco, Till Becker, Martin Gogolla, Karl A. Hribernik, and Klaus-Dieter Thoben (2016). “Interoperability of Logistics Artifacts: An Approach for Information Exchange Through Transformation Mechanisms”. In: *Dynamics in Logistics*. Ed. by Michael Freitag, Herbert Kotzab, and Jürgen

Pannek. Lecture Notes in Logistics. Cham: Springer International Publishing, pp. 469–479. ISBN: 978-3-319-45116-9. DOI: 10.1007/978-3-319-45117-6_41.

[Fuchs and Otto 2015]Fuchs, Christoph and Andreas Otto (2015). "Value of IT in supply chain planning". In: *Journal of Enterprise Information Management* 28.1, pp. 77–92. ISSN: 1741-0398. DOI: 10.1108/JEIM-07-2013-0053.

[Gangemi 2005]Gangemi, Aldo (2005). "Ontology Design Patterns for Semantic Web Content". In: *The semantic Web - ISWC 2005*. Ed. by Yolanda Gil, Enrico Motta, V. Richard Benjamins, and Mark A. Musen. Vol. 3729. Lecture Notes in Computer Science. Berlin: Springer, pp. 262–276. ISBN: 978-3-540-29754-3. DOI: 10.1007/11574620{_}21.

[Gangemi, Gómez-Pérez, et al. 2007]Gangemi, Aldo, Asunción Gómez-Pérez, Valentina Presutti, and Mari Carmen Suárez-Figueroa (2007). "Towards a catalog of owl-based ontology design patterns". In:

[Gangemi and Presutti 2009]Gangemi, Aldo and Valentina Presutti (2009). "Ontology design patterns". In: *Handbook on Ontologies*. Ed. by Steffen Staab and Rudi Studer. Berlin, Heidelberg: Springer, pp. 221–243. ISBN: 978-3-540-70999-2.

[Geng et al. 2010]Geng, Xiuli, Xuening Chu, Deyi Xue, and Zaifang Zhang (2010). "An integrated approach for rating engineering characteristics' final importance in product-service system development". In: *Computers & Industrial Engineering* 59.4, pp. 585–594. ISSN: 03608352. DOI: 10.1016/j.cie.2010.07.002.

[Giunchiglia et al. 2010]Giunchiglia, Fausto, Feroz Farazi, Letizia Tanca, and Roberto de Virgilio (2010). "The Semantic Web Languages". In: *Semantic Web Information Management*. Ed. by Roberto de Virgilio. Berlin: Springer, pp. 25–38. ISBN: 978-3-642-04328-4. DOI: 10.1007/978-3-642-04329-1{_}3.

[Glöckner, Augenstein, et al. 2014]Glöckner, Michael, Christoph Augenstein, and André Ludwig (2014). "Metamodel of a Logistics Service Map". In: *Business Information Systems*. Ed. by Wil van der Aalst, John Mylopoulos, Michael Rosemann, Michael J. Shaw, Clemens Szyperski, Witold Abramowicz, and Angelika Kokkinaki. Vol. 176. Lecture Notes in Business Information Processing. Cham: Springer International Publishing, pp. 185–196. ISBN: 978-3-319-06694-3. DOI: 10.1007/978-3-319-06695-0{_}16.

[Glöckner and Ludwig 2013]Glöckner, Michael and André Ludwig (2013). "Towards a Logistics Service Map: Support for Logistics Service Engineering and Management". In: *Pioneering solutions in supply chain performance management: Proceedings of the Hamburg International Conference of Logistics (HICL) 2013*. Ed. by Thorsten Blecker, Wolfgang Kersten, and Christian Ringle. Vol. 17. Supply chain, logistics and operations management. Lohmar, Köln: Eul, pp. 309–324. ISBN: 978-3844102673.

[Glöckner and Ludwig 2017a]Glöckner, Michael and André Ludwig (2017a). "LoSe ODP - An Ontology Design Pattern for Logistics Services". In: *Advances in ontology design and patterns*. Ed. by Karl Hammar. Studies on the Semantic Web. Berlin and Amsterdam: AKA and IOS Press. ISBN: 978-1-61499-825-9. URL: http://ontologydesignpatterns.org/wiki/images/f/fb/WOP2016_paper_14.pdf.

[Glöckner and Ludwig 2017b]— (2017b). "LoSeMa ODP - An Ontology Design Pattern for Logistics Service Maps". In: *Post-Workshop Proceedings*. Ed. by Eva Blomqvist, Oscar Corcho, Matthew Horridge, Rinke Hoekstra, and David Carral. URL: http://ontologydesignpatterns.org/wiki/images/a/a0/Paper-10.pdf.

[Glöckner and Ludwig 2017c]— (2017c). "Ontological structuring of logistics services". In: *Proceedings of the International Conference on Web Intelligence - WI '17*. Ed. by Axel Ngonga, Amit Sheth, yin Wang, Elizabeth Chang, Dominik Ślęzak, Bogdan Franczyk, Rainer Alt, and Xiaohui Tao. New York, New York, USA: ACM Press, pp. 146–153. ISBN: 9781450349512. DOI: 10.1145/3106426.3106538.

[Glöckner and Ludwig 2019]— (2019). "Towards the Conception of Cloud Logistics: Engineering and Management of Modular Cloud Logistics Services in the Context of Flexible Future Supply Chains". In: (publication ready).

[Glöckner et al. 2016a]Glöckner, Michael, André Ludwig, and Bogdan Franczyk (2016a). "A Reference Architecture for the Logistics Service Map: Structuring and Composing Logistics Services in Logistics Networks". In: *2016 IEEE International Conference on Computer and Information Technology (CIT)*. IEEE, pp. 644–651. ISBN: 978-1-5090-4314-9. DOI: 10.1109/CIT.2016.56.

[Glöckner et al. 2016b]— (2016b). "How Low Should You Go? - Conceptualization of the Service Granularity Framework". In: *24th European Conference on Information Systems (ECIS 2016)*. Proceedings of the European Conference on Information Systems, ResearchPaper32.

[Glöckner et al. 2017]— (2017). "Go with the Flow - Design of Cloud Logistics Service Blueprints". In: *Proceedings of the Annual Hawaii International Conference on System Sciences (HICSS)*, pp. 5058–5067. DOI: 10.24251/HICSS.2017.614.

[Glöckner, Mutke, Augenstein, et al. 2015]Glöckner, Michael, Stefan Mutke, Christoph Augenstein, and André Ludwig (2015). "Planning of Composite Logistics Services: Model-Driven Engineering and Evaluation". In: *Enterprise Information Systems*. Ed. by Slimane Hammoudi, Leszek Maciaszek, Ernest Teniente, Olivier Camp, and José Cordeiro. Vol. 241. Lecture Notes in Business Information Processing. Cham: Springer International Publishing, pp. 364–384. ISBN: 978-3-319-29132-1. DOI: 10.1007/978-3-319-29133-8{_}18.

[Glöckner, Mutke, and Ludwig 2015]Glöckner, Michael, Stefan Mutke, and André Ludwig (2015). “Engineering and Evaluation of Process Alternatives in Tactical Logistics Planning”. In: *17th International Conference on Enterprise Information Systems*, pp. 166–176. DOI: 10.5220/0005377801660176.

[Glöckner, Niehoff, et al. 2017]Glöckner, Michael, Tim Niehoff, Benjamin Gaunitz, and André Ludwig (2017). “Logistics Service Map Prototype”. In: *Designing the Digital Transformation*. Ed. by Alexander Mädche, Jan Vom Brocke, and Alan Hevner. Cham: Springer International Publishing. ISBN: 978-3-319-59143-8. DOI: 10.1007/978-3-319-59144-5{_}26. URL: https://doi.org/10.1007/978-3-319-59144-5_26.

[Glöckner, Schwarzbach, et al. 2014]Glöckner, Michael, Björn Schwarzbach, Andreas Barton, André Ludwig, and Bogdan Franczyk (2014). “Visual enhancement of service maps in logistics clouds”. In: Annals of Computer Science and Information Systems. IEEE, pp. 1301–1310. DOI: 10.15439/2014F360.

[Goel 1997]Goel, A. K. (1997). “Design, analogy, and creativity”. In: *IEEE Expert* 12.3, pp. 62–70. ISSN: 0885-9000. DOI: 10.1109/64.590078.

[Goldkuhl 2002]Goldkuhl, Göran (2002). “Anchoring scientific abstractions–ontological and linguistic determination following socio-instrumental pragmatism”. In: *Proceedings of European Conference on Research Methods in Business, Reading*.

[Goos et al. 1999]Goos, G., J. Hartmanis, J. van Leeuwen, Peter P. Chen, Jacky Akoka, Hannu Kangassalu, and Bernhard Thalheim (1999). *Conceptual Modeling*. Vol. 1565. Berlin, Heidelberg: Springer Berlin Heidelberg. ISBN: 978-3-540-65926-6. DOI: 10.1007/3-540-48854-5.

[Gregor and Hevner 2013]Gregor, Shirley and Alan Hevner (2013). “Positioning and presenting design science research for maximum impact”. In: *MIS Quarterly* 37.2.

[Gregor and Jones 2007]Gregor, Shirley and David Jones (2007). “The Anatomy of a Design Theory”. In: *Journal of he Association for Information Systems* 8.5, pp. 312–335.

[Gropengießer and Sattler 2014]Gropengießer, Francis and Kai-Uwe Sattler (2014). “Database Backend as a Service: Automatic Generation, Deployment, and Management of Database Backends for Mobile Applications”. In: *Datenbank-Spektrum* 14.2, pp. 85–95. ISSN: 1618-2162. DOI: 10.1007/s13222-014-0157-y.

[Gudehus and Kotzab 2012]Gudehus, Timm and Herbert Kotzab (2012). *Comprehensive Logistics*. Berlin, Heidelberg: Springer Berlin Heidelberg. ISBN: 978-3-642-24366-0. DOI: 10.1007/978-3-642-24367-7.

[Hall et al. 2012]Hall, Dianne J., Joseph B. Skipper, Benjamin T. Hazen, and Joe B. Hanna (2012). “Inter–organizational IT use, cooperative attitude, and inter–

organizational collaboration as antecedents to contingency planning effectiveness". In: *The International Journal of Logistics Management* 23.1, pp. 50–76. ISSN: 0957-4093. DOI: 10.1108/09574091211226920.

[Handfield et al. 2013]Handfield, Robert, Frank Straube, Hans-Christian Pfohl, and Andreas Wieland (2013). *Embracing global logistics complexity to drive market advantage*. Trends and strategies in logistics and supply chain management. Hamburg: DVV Media Group. ISBN: 978-3-87154-481-1.

[Hara et al. 2009]Hara, Tatsunori, Tamio Arai, Yoshiki Shimomura, and Tomohiko Sakao (2009). "Service CAD system to integrate product and human activity for total value". In: *CIRP Journal of Manufacturing Science and Technology* 1.4, pp. 262–271. ISSN: 17555817. DOI: 10.1016/j.cirpj.2009.06.002.

[Hartmann and Grahl 2012]Hartmann, Evi and Alexander de Grahl (2012). "The Flexibility of Logistics Service Providers and its Impact on Customer Loyalty – An Empirical Study". In: *Success Factors in Logistics Outsourcing*. Ed. by Alexander de Grahl. Wiesbaden: Gabler Verlag, pp. 7–51. ISBN: 978-3-8349-3355-3. DOI: 10.1007/978-3-8349-7084-8{_}2.

[Hazen and Byrd 2012]Hazen, Benjamin T. and Terry Anthony Byrd (2012). "Toward creating competitive advantage with logistics information technology". In: *International Journal of Physical Distribution & Logistics Management* 42.1, pp. 8–35. ISSN: 0960-0035. DOI: 10.1108/09600031211202454.

[Helo and Szekely 2005]Helo, Petri and Bulcsu Szekely (2005). "Logistics information systems". In: *Industrial Management & Data Systems* 105.1, pp. 5–18. ISSN: 0263-5577. DOI: 10.1108/02635570510575153.

[Hevner et al. 2004]Hevner, Alan, Salvatore March, Jinsoo Park, and Suddha Ram (2004). "Design Science in Information Systems Research". In: *MIS Quarterly* 28.1, pp. 75–105.

[Hicks et al. 2015]Hicks, Diana, Paul Wouters, Ludo Waltman, Sarah de Rijcke, and Ismael Rafols (2015). "Bibliometrics: The Leiden Manifesto for research metrics". In: *Nature - international weekly journal of science* 520.7548, pp. 429–431. URL: https://www.nature.com/polopoly_fs/1.17351!/menu/main/topColumns/topLeftColumn/pdf/520429a.pdf.

[Hingley et al. 2011]Hingley, Martin, Adam Lindgreen, David B. Grant, and Charles Kane (2011). "Using fourth–party logistics management to improve horizontal collaboration among grocery retailers". In: *Supply Chain Management: An International Journal* 16.5, pp. 316–327. ISSN: 1359-8546. DOI: 10.1108/13598541111155839.

[Hirsch 2005]Hirsch, J. E. (2005). "An index to quantify an individual's scientific research output". In: *Proceedings of the National Academy of Sciences of the United States of America* 102.46, pp. 16569–16572. ISSN: 0027-8424. DOI: 10.1073/pnas.0507655102.

[Hitzler et al. 2010]Hitzler, Pascal, Markus Krötzsch, and Sebastian Rudolph (2010). *Foundations of Semantic Web technologies*. Chapman & Hall/CRC textbooks in computing. Boca Raton: CRC Press. ISBN: 978-1420090505.

[Hoekstra 2009]Hoekstra, Rinke Jan (2009). *Ontology Representation - Design Patterns and Ontologies that Make Sense*. Dissertation. URL: `http://hdl.handle.net/11245/1.317612`.

[Hofmann and Rüsch 2017]Hofmann, Erik and Marco Rüsch (2017). "Industry 4.0 and the current status as well as future prospects on logistics". In: *Computers in Industry* 89, pp. 23–34. ISSN: 01663615. DOI: `10.1016/j.compind.2017.04.002`.

[Holmes 2016]Holmes, Simon (2016). *Getting MEAN With Mongo, Express, Angular, and Node*. Shelter Island, NY: Manning Publications. ISBN: 1617292036. URL: `http://proquest.tech.safaribooksonline.de/9781617292033`.

[Holtkamp et al. 2010]Holtkamp, Bernhard, Sebasti Steinbuss, Heiko Gsell, Thorsten Loeffeler, and Ulrich Springer (2010). "Towards a Logistics Cloud". In: *2010 Sixth International Conference on Semantics Knowledge and Grid (SKG)*, pp. 305–308. DOI: `10.1109/SKG.2010.46`.

[Hoxha et al. 2010]Hoxha, Julia, Andreas Scheuermann, and Stephan Bloehdorn (2010). "An approach to formal and semantic representation of logistics services". In: *Proceedings of the Workshop on Artificial Intelligence and Logistics (AILog), 19th European Conference on Artificial Intelligence (ECAI 2010), Lisbon, Portugal*, pp. 73–78.

[Jaekel 2019]Jaekel, Falco (2019). *Cloud Logistics*. Wiesbaden: Springer Fachmedien Wiesbaden. ISBN: 978-3-658-22836-1. DOI: `10.1007/978-3-658-22837-8`.

[Jager et al. 2007]Jager, Kerstin, Sandor Ujvari, and Olli Pekka Hilmola (2007). "Operating as a third-party logistics integrator without any distribution operations ownership". In: *International Journal of Services and Standards* 3.2, p. 154. ISSN: 1740-8849. DOI: `10.1504/IJSS.2007.012926`.

[Jede and Teuteberg 2016]Jede, Andreas and Frank Teuteberg (2016). "Towards cloud-based supply chain processes". In: *The International Journal of Logistics Management* 27.2, pp. 438–462. ISSN: 0957-4093. DOI: `10.1108/IJLM-09-2014-0139`.

[Kang and Wimmer 2008]Kang, Myung-Joo and Robert Wimmer (2008). "Product service systems as systemic cures for obese consumption and production". In: *Journal of Cleaner Production* 16.11, pp. 1146–1152. ISSN: 09596526. DOI: `10.1016/j.jclepro.2007.08.009`.

[Kersten et al. 2014]Kersten, Wolfgang, Birgit von See, and Henning Skirde (2014). "Identification of Megatrends Affecting Complexity in Logistics Systems". In: *Next generation supply chains*. Ed. by Wolfgang Kersten. Berlin: epubli. ISBN: 9783844298796.

[Kieser and Osterloh 2012]Kieser, Alfred and Margit Osterloh (2012). “Den Unfug schnell beenden: Professoren boykottieren das BWL-Ranking des Handelsblatts”. In: *Wissenschaftsmanagement Online*, pp. 820–821. URL: `http://www.wissenschaftsmanagement-online.de/sites/www.wissenschaftsmanagement-online.de/files/migrated_wimoarticle/ful_10-2012_Kieser_Osterloh.pdf`.

[Kitchenham and Charters 2007]Kitchenham, Barbara and Stuart Charters (2007). “Guidelines for performing systematic literature reviews in software engineering: Technical report, Ver. 2.3 EBSE Technical Report. EBSE”. PhD thesis. Keele University, UK and Lincoln University, NZ.

[Klinkmüller et al. 2011]Klinkmüller, Christopher, Robert Kunkel, André Ludwig, and Bogdan Franczyk (2011). “The Logistics Service Engineering and Management Platform: Features, Architecture, Implementation”. In: *Business Information Systems*. Ed. by Witold Abramowicz. Lecture Notes in Business Information Processing. Berlin, Heidelberg: Springer-Verlag GmbH Berlin Heidelberg, pp. 242–253. ISBN: 9783642218293. URL: `https://link.springer.com/chapter/10.1007%2F978-3-642-21863-7_21`.

[Krampe et al. 2012]Krampe, Horst, Hans-Joachim Lucke, and Michael Schenk, eds. (2012). *Grundlagen der Logistik: Einführung in Theorie und Praxis logistischer Systeme*. 4. völlig neu bearbeitete und erweiterte Auflage. Logistik Wissen. München: Huss-Verlag GmbH. ISBN: 978-3941418806.

[Kückelhaus et al. 2016]Kückelhaus, Markus, Gina Chung, and Dora Virag (2016). *LOGISTICS TREND RADAR: Delivering insight today. Creating value tomorrow!* Ed. by DHL Customer Solutions & Innovation. URL: `http://www.dhl.com/content/dam/downloads/g0/about_us/logistics_insights/dhl_logistics_trend_radar_2016.pdf`.

[Langley and Long 2016]Langley, John and Mindy Long (2016). “2016 Third-Party Logistics Study: The State of Logistics Outsourcing: Results and Findings of the 20th Annual Study”. In: 20. URL: `http://www.otmbe.org/infotheek/downloads/informatie/652-3pl-report/file`.

[Langley and Long 2017]— (2017). “2017 Third-Party Logistics Study: The State of Logistics Outsourcing: Results and Findings of the 21st Annual Study”. In: 21.

[Langley and Long 2018]— (2018). “2018 Third-Party Logistics Study: The State of Logistics Outsourcing: Results and Findings of the 22st Annual Study”. In: 22.

[Lantz 1986]Lantz, Kenneth E. (1986). *The prototyping methodology*. Englewood Cliffs, N.J.: Prentice-Hall. ISBN: 0-8359-5897-3.

[Jörg Leukel, Jacob, et al. 2011]Leukel, Jörg, Ansger Jacob, Paul Karaenke, Stefan Kirn, and Achim Klein (2011). “Individualization of Goods and Services: Towards a

Logistics Knowledge Infrastructure for Agile Supply Chains." In: *Proceedings of the AAAI Spring Symposium 2011*. Stanford.

[Jörg Leukel, Kirn, et al. 2011]Leukel, Jörg, Stefan Kirn, and Thomas Schlegel (2011). "Supply Chain as a Service: A Cloud Perspective on Supply Chain Systems". In: *IEEE Systems Journal* 5.1, pp. 16–27. ISSN: 1932-8184. DOI: 10.1109/JSYST.2010.2100197.

[Levy and Ellis 2006]Levy, Yair and Timothy J. Ellis (2006). "A Systems Approach to Conduct an Effective Literature Review in Support of Information Systems Research". In: *Informing Science Journal* Volume 9, pp. 181–212.

[Li et al. 2013]Li, Wenfeng, Ye Zhong, Xun Wang, and Yulian Cao (2013). "Resource virtualization and service selection in cloud logistics". In: *Journal of Network and Computer Applications* 36.6, pp. 1696–1704. ISSN: 10848045. DOI: 10.1016/j.jnca.2013.02.019.

[Liu et al. 2015]Liu, Chen, Baofeng Huo, Shulin Liu, and Xiande Zhao (2015). "Effect of information sharing and process coordination on logistics outsourcing". In: *Industrial Management & Data Systems* 115.1, pp. 41–63. ISSN: 0263-5577. DOI: 10.1108/IMDS-08-2014-0233.

[Lohre et al. 2015]Lohre, Dirk, Roland Pfennig, Viktoria Poerschke, and Ruben Gotthardt (2015). "Grundlagen der Logistik". In: *Nachhaltigkeitsmanagement für Logistikdienstleister*. Ed. by Dirk Lohre, Roland Pfennig, Viktoria Poerschke, and Ruben Gotthardt. Wiesbaden: Springer Fachmedien Wiesbaden, pp. 5–15. ISBN: 978-3-658-03124-4. DOI: 10.1007/978-3-658-03125-1{_}2.

[Lorenz and Löffler 2015]Lorenz, Daniela and Andreas Löffler (2015). "Robustness of personal rankings: The Handelsblatt example". In: *Business Research* 8.2, pp. 189–212. ISSN: 2198-3402. DOI: 10.1007/s40685-015-0020-5.

[Lu et al. 2013]Lu, Yan, Hervé Panetto, Yihua Ni, and Xinjian Gu (2013). "Ontology alignment for networked enterprise information system interoperability in supply chain environment". In: *International Journal of Computer Integrated Manufacturing* 26.1-2, pp. 140–151. DOI: 10.1080/0951192X.2012.681917.

[Luftman et al. 2015]Luftman, Jerry, Barry Derksen, Rajeev Dwivedi, Martin Santana, Hossein S. Zadeh, and Eduardo Rigoni (2015). "Influential IT management trends: An international study". In: *Journal of Information Technology* 30.3, pp. 293–305. ISSN: 0268-3962. DOI: 10.1057/jit.2015.18.

[Mallapragada et al. 2015]Mallapragada, Girish, Rajdeep Grewal, Raj Mehta, and Ravi Dharwadkar (2015). "Virtual interorganizational relationships in business-to-business electronic markets: Heterogeneity in the effects of organizational interdependence on relational outcomes". In: *Journal of the Academy of Marketing Science* 43.5, pp. 610–628. ISSN: 0092-0703. DOI: 10.1007/s11747-014-0411-8.

[Marston et al. 2011]Marston, Sean, Zhi Li, Subhajyoti Bandyopadhyay, Juheng Zhang, and Anand Ghalsasi (2011). "Cloud computing — The business perspective". In: *Decision Support Systems* 51.1, pp. 176–189. ISSN: 01679236. DOI: 10.1016/j.dss.2010.12.006.

[McKinnon 2013]McKinnon, Alan C. (2013). "Starry–eyed: Journal rankings and the future of logistics research". In: *International Journal of Physical Distribution & Logistics Management* 43.1, pp. 6–17. ISSN: 0960-0035. DOI: 10.1108/09600031311293228.

[McKinnon 2017]— (2017). "Starry-eyed II: The logistics journal ranking debate revisited". In: *International Journal of Physical Distribution & Logistics Management* 47.6, pp. 431–446. ISSN: 0960-0035. DOI: 10.1108/IJPDLM-02-2017-0097.

[Mell and Grance 2011]Mell, Peter and Tim Grance (2011). "The NIST definition of cloud computing". In: *Computer Security Division, Information Technology Laboratory, National Institute of Standards and Technology Gaithersburg.*

[Mentzer et al. 2001]Mentzer, John T., William DeWitt, James S. Keebler, Soonhong Min, Nancy W. Nix, Carlo D. Smith, and Zach G. Zacharia (2001). "DEFINING SUPPLY CHAIN MANAGEMENT". In: *Journal of Business Logistics* 22.2, pp. 1–25. ISSN: 07353766. DOI: 10.1002/j.2158-1592.2001.tb00001.x.

[Merton 1968]Merton, Robert King (1968). *Social theory and social structure*. Simon and Schuster.

[Metzger et al. 2012]Metzger, Andreas, Rod Franklin, and Yagil Engel (2012). "Predictive Monitoring of Heterogeneous Service-Oriented Business Networks: The Transport and Logistics Case". In: *Annual SRII global conference (SRII), 2012*. Piscataway, NJ: IEEE, pp. 313–322. ISBN: 978-1-4673-2318-5. DOI: 10.1109/SRII.2012.42.

[Millet et al. 2013]Millet, Pierre-Alain, Lorraine Trilling, Thierry Moyaux, and Omar Sakka (2013). "Ontology of SCOR for the Strategic Alignment of Organizations and Information Systems". In: *Supply Chain Performance*. Ed. by Val?rie Botta-Genoulaz, Jean-Pierre Campagne, Daniel Llerena, and Claude Pellegrin. ISTE. London: Wiley, pp. 171–210. ISBN: 978-1-84821-219-0.

[Miorandi et al. 2012]Miorandi, Daniele, Sabrina Sicari, Francesco de Pellegrini, and Imrich Chlamtac (2012). "Internet of things: Vision, applications and research challenges". In: *Ad Hoc Networks* 10.7, pp. 1497–1516. ISSN: 15708705. DOI: 10.1016/j.adhoc.2012.02.016.

[Mokyr 2002]Mokyr, Joel (2002). *The gifts of Athena: Historical origins of the knowledge economy*. Princeton University Press.

[Montreuil et al. 2013]Montreuil, Benoit, Russell D. Meller, and Eric Ballot (2013). "Physical Internet Foundations". In: *Service Orientation in Holonic and Multi*

Agent Manufacturing and Robotics. Ed. by Theodor Borangiu, Andre Thomas, and Damien Trentesaux. Vol. 472. Studies in Computational Intelligence. Berlin, Heidelberg: Springer Berlin Heidelberg, pp. 151–166. ISBN: 978-3-642-35851-7. DOI: 10.1007/978-3-642-35852-4{_}10.

[Morelli 2003]Morelli, N. (2003). "Product-service systems, a perspective shift for designers: A case study: the design of a telecentre". In: *Design Studies* 24.1, pp. 73–99. ISSN: 0142694X. DOI: 10.1016/S0142-694X(02)00029-7.

[Mutke et al. 2015]Mutke, Stefan, Christoph Augenstein, Martin Roth, André Ludwig, and Bogdan Franczyk (2015). "Real-time information acquisition in a model-based integrated planning environment for logistics contracts". In: *The Journal of Object Technology* 14.1, 2:1. ISSN: 1660-1769. DOI: 10.5381/jot.2015.14.1.a2.

[Negri et al. 2017]Negri, Elisa, Sara Perotti, Luca Fumagalli, Gino Marchet, and Marco Garetti (2017). "Modelling internal logistics systems through ontologies". In: *Computers in Industry* 88, pp. 19–34. ISSN: 01663615. DOI: 10.1016/j.compind.2017.03.004.

[Newell, Herbert Alexander Simon, et al. 1972]Newell, Allen, Herbert Alexander Simon, et al. (1972). *Human problem solving*. Vol. 104. Prentice-Hall Englewood Cliffs, NJ.

[Newton 1675]Newton, Isaac (1675). *Letter from Sir Isaac Newton to Robert Hooke*. URL: http://digitallibrary.hsp.org/index.php/Detail/Object/Show/object_id/9285.

[Nkomo 2009]Nkomo, S. M. (2009). "The Seductive Power of Academic Journal Rankings: Challenges of Searching for the Otherwise". In: *Academy of Management Learning & Education* 8.1, pp. 106–121. ISSN: 1537-260X. DOI: 10.5465/AMLE.2009.37012184.

[Österle, Becker, et al. 2011]Österle, Hubert, Jörg Becker, et al. (2011). "Memorandum on design-oriented information systems research". In: *European Journal of Information Systems* 20.1, pp. 7–10. ISSN: 0960-085X. DOI: 10.1057/ejis.2010.55.

[Österle, Winter, et al. 2010]Österle, Hubert, Robert Winter, and Walter Brenner, eds. (2010). *Gestaltungsorientierte Wirtschaftsinformatik: Ein Plädoyer für Rigor und Relevanz*. Nürnberg: Infowerk. ISBN: 9783000303104.

[Papazoglou and van Heuvel 2006]Papazoglou, Michael P. and Willem-Jan Den van Heuvel (2006). "Service-oriented design and development methodology". In: *International Journal of Web Engineering and Technology* 2.4, p. 412. ISSN: 1476-1289. DOI: 10.1504/IJWET.2006.010423.

[Peffers, Rothenberger, et al. 2012]Peffers, Ken, Marcus Rothenberger, Tuure Tuunanen, and Reza Vaezi (2012). "Design Science Research Evaluation". In: *Design science research in information systems*. Ed. by Ken Peffers. Vol. 7286. Lecture Notes in Computer Science. Heidelberg: Springer, pp. 398–410. ISBN: 978-3-642-29862-2. DOI: 10.1007/978-3-642-29863-9{_}29.

[Peffers, Tuunanen, et al. 2007]Peffers, Ken, Tuure Tuunanen, Marcus A. Rothenberger, and Samir Chatterjee (2007). "A Design Science Research Methodology for Information Systems Research". In: *Journal of Management Information Systems* 24.3, pp. 45–77. ISSN: 0742-1222. DOI: 10.2753/MIS0742-1222240302.

[Peters et al. 2007]Peters, Melvyn, James Cooper, Robert C. Lieb, and Hugh L. Randall (2007). "The Third-Party Logistics Industry in Europe: Provider Perspectives on the Industry's Current Status and Future Prospects". In: *International Journal of Logistics Research and Applications* 1.1, pp. 9–25. ISSN: 1367-5567. DOI: 10.1080/13675569808962035.

[Pfohl 2010]Pfohl, Hans-Christian (2010). *Logistiksysteme*. Berlin, Heidelberg: Springer Berlin Heidelberg. ISBN: 978-3-642-04161-7. DOI: 10.1007/978-3-642-04162-4.

[Pfohl et al. 2013]Pfohl, Hans-Christian, Steffen Wagner, and Andreas Ries (2013). *4th Party Logistics – Chancen und Herausforderungen*. URL: https://assets.kpmg.com/content/dam/kpmg/pdf/2014/05/KPMG-Studie-4PL.pdf.

[Prajogo and Olhager 2012]Prajogo, Daniel and Jan Olhager (2012). "Supply chain integration and performance: The effects of long-term relationships, information technology and sharing, and logistics integration". In: *International Journal of Production Economics* 135.1, pp. 514–522. ISSN: 09255273. DOI: 10.1016/j.ijpe.2011.09.001.

[Preist et al. 2005]Preist, Chris, Javier Esplugas-Cuadrado, Steven A. Battle, Stephan Grimm, and Stuart K. Williams (2005). "Automated Business-to-Business Integration of a Logistics Supply Chain Using Semantic Web Services Technology". In: *The semantic Web - ISWC 2005*. Ed. by Yolanda Gil, Enrico Motta, V. Richard Benjamins, and Mark A. Musen. Vol. 3729. Lecture Notes in Computer Science. Berlin: Springer, pp. 987–1001. ISBN: 978-3-540-29754-3. DOI: 10.1007/11574620{_}70.

[Presutti and Gangemi 2008]Presutti, Valentina and Aldo Gangemi (2008). "Content Ontology Design Patterns as Practical Building Blocks for Web Ontologies". In: *Conceptual modeling - ER 2008*. Ed. by Qing Li. Vol. 5231. LNCS sublibrary. Information systems and application, incl. Internet/Web, and HCI. Berlin: Springer, pp. 128–141. ISBN: 978-3-540-87876-6. DOI: 10.1007/978-3-540-87877-3{_}11.

[Purao 2002]Purao, Sandeep (2002). "Design research in the technology of information systems: Truth or dare". In: *GSU Department of CIS Working Paper*, pp. 45–77.

[Rai et al. 2012]Rai, Arun, Paul A. Pavlou, Ghiyoung Im, and Steve Du (2012). "Interfirm IT Capability Profiles and Communications for Cocreating Relational Value: Evidence from the Logistics Industry". In: *MIS Quarterly* 36.1, pp. 233–262. URL: http://dl.acm.org/citation.cfm?id=2208955.2208970.

[Rajahonka et al. 2013]Rajahonka, Mervi, Anu Bask, and Mervi Lipponen (2013). "Modularity and customisation in LSPs' service strategies". In: *International Journal of Services and Operations Management* 16.2, p. 174. ISSN: 1744-2370. DOI: 10.1504/IJSOM.2013.056165.

[Ralyté and Rolland 2001]Ralyté, Jolita and Colette Rolland (2001). "An Assembly Process Model for Method Engineering". In: *Advanced Information Systems Engineering*. Ed. by Gerhard Goos, Juris Hartmanis, Jan van Leeuwen, Klaus R. Dittrich, Andreas Geppert, and Moira C. Norrie. Vol. 2068. Lecture Notes in Computer Science. Berlin, Heidelberg: Springer Berlin Heidelberg, pp. 267–283. ISBN: 978-3-540-42215-0. DOI: 10.1007/3-540-45341-5{_}18.

[Raubenheimer 2010]Raubenheimer, Heike (2010). *Kostenmanagement im Outsourcing von Logistikleistungen*. Wiesbaden: Springer Fachmedien. ISBN: 978-3-8349-8473-9.

[Rauschecker et al. 2011]Rauschecker, Ursula, Matthias Meier, Ralf Muckenhirn, Arthur Yip, Ananda Jagadeesan, and Jonathan Corney (2011). "Cloud-Based Manufacturing-as-a-Service Environment for Customized Products". In: *eChallenges 2011*. Ed. by Paul Cunningham and Miriam Cunningham. Dublin: IIMC, International Information Management Corporation, pp. 1–8. ISBN: 1905824270. URL: http://strathprints.strath.ac.uk/38573/1/Cloud_based_Manufacturing_as_a_Service_Environment_for_Customized_Products.pdf.

[Ritchey 2013]Ritchey, Tom (2013). *General Morphological Analysis - A general method for non-quantified modelling*. URL: http://www.swemorph.com/pdf/gma.pdf.

[Rodan and Galunic 2004]Rodan, Simon and Charles Galunic (2004). "More than network structure: How knowledge heterogeneity influences managerial performance and innovativeness". In: *Strategic Management Journal* 25.6, pp. 541–562. ISSN: 0143-2095. DOI: 10.1002/smj.398.

[Roth et al. 2014]Roth, Martin, Stefan Mutke, Axel Klarmann, Bogdan Franczyk, and Andre Ludwig (2014). "Real-timeservice profiling for the efficient simulation of logistics networks". In: *2014 International Conference on Advanced Logistics and Transport (ICALT)*. Piscataway, NJ: IEEE, pp. 253–258. ISBN: 978-1-4799-4839-0. DOI: 10.1109/ICAdLT.2014.6866320.

[Rowe 1991]Rowe, Peter G. (1991). *Design thinking*. MIT press.

[Rowlinson et al. 2015]Rowlinson, Michael, Charles Harvey, Aidan Kelly, Huw Morris, and Emanuela Todeva (2015). "Accounting for research quality: Research audits and the journal rankings debate". In: *Critical Perspectives on Accounting* 26, pp. 2–22. ISSN: 10452354. DOI: 10.1016/j.cpa.2013.05.012.

[Ryu et al. 2009]Ryu, Il, SoonHu So, and Chulmo Koo (2009). “The role of partnership in supply chain performance”. In: *Industrial Management & Data Systems* 109.4, pp. 496–514. ISSN: 0263-5577. DOI: 10.1108/02635570910948632.

[Sakka et al. 2011]Sakka, Omar, Pierre-Alain Millet, and Valérie Botta-Genoulaz (2011). “An ontological approach for strategic alignment: A supply chain operations reference case study”. In: *International Journal of Computer Integrated Manufacturing* 24.11, pp. 1022–1037. DOI: 10.1080/0951192X.2011.575798.

[Scheuermann and Hoxha 2012]Scheuermann, Andreas and Julia Hoxha (2012). “Ontologies for Intelligent Provision of Logistics Services”. In: *ICIW 2012 : The Seventh International Conference on Internet and Web Applications and Services*, pp. 106–111.

[Scheuermann and Joerg Leukel 2014]Scheuermann, Andreas and Joerg Leukel (2014). “Supply chain management ontology from an ontology engineering perspective”. In: *Computers in Industry* 65.6, pp. 913–923. ISSN: 01663615. DOI: 10.1016/j.compind.2014.02.009.

[Schleich et al. 2017]Schleich, Benjamin, Nabil Anwer, Luc Mathieu, and Sandro Wartzack (2017). “Shaping the digital twin for design and production engineering”. In: *CIRP Annals* 66.1, pp. 141–144. ISSN: 00078506. DOI: 10.1016/j.cirp.2017.04.040.

[Schmidt and Wilhelm 2000]Schmidt, G. and Wilbert E. Wilhelm (2000). “Strategic, tactical and operational decisions in multi-national logistics networks: A review and discussion of modelling issues”. In: *International Journal of Production Research* 38.7, pp. 1501–1523. ISSN: 0020-7543. DOI: 10.1080/002075400188690.

[Schütz and Tomasgard 2011]Schütz, Peter and Asgeir Tomasgard (2011). “The impact of flexibility on operational supply chain planning”. In: *International Journal of Production Economics* 134.2, pp. 300–311. ISSN: 09255273.

[Schwarzbach, Glöckner, Franczyk, et al. 2017]Schwarzbach, Björn, Michael Glöckner, Bogdan Franczyk, and André Ludwig (2017). “Evaluation of User Specific Privacy Policy Architecture for Collaborative BPaaS on the Example of Logistics”. In: *Information Technology for Management*. Ed. by Ewa Ziemba. Cham: Springer International Publishing. ISBN: 978-3-319-53075-8. DOI: 10.1007/978-3-319-53076-5{_}8. URL: https://link.springer.com/chapter/10.1007/978-3-319-53076-5_8.

[Schwarzbach, Glöckner, Schier, et al. 2016]Schwarzbach, Björn, Michael Glöckner, Arkadius Schier, Marcin Robak, and Bogdan Franczyk (2016). “User specific privacy policies for collaborative BPaaS on the example of logistics”. In: *Computer Science and Information Systems (FedCSIS), 2016 Federated Conference on*. IEEE, pp. 1205–1213. DOI: 10.15439/2016F400.

[Schwemmer and Pflaum 2017]Schwemmer, Martin and Alexander Pflaum (2017). *TOP 100 in European transport and logistics services: Market sizes, market segments and market leaders in the European logistics industry.* 2017th ed. Hamburg: DVV Media Group. ISBN: 978-3-87154-615-0.

[Selviaridis and Spring 2007]Selviaridis, Konstantinos and Martin Spring (2007). "Third party logistics: A literature review and research agenda". In: *The International Journal of Logistics Management* 18.1, pp. 125–150. ISSN: 0957-4093. DOI: 10.1108/09574090710748207.

[Shugan 2003]Shugan, Steven M. (2003). "Editorial: Journal Rankings: Save the Outlets for Your Research". In: *Marketing Science* 22.4, pp. 437–441. ISSN: 0732-2399. DOI: 10.1287/mksc.22.4.437.24904.

[Herbert A. Simon et al. 1981]Simon, Herbert A., Patrick W. Langley, and Gary L. Bradshaw (1981). "Scientific discovery as problem solving". In: *Synthese* 47.1, pp. 1–27. ISSN: 0039-7857. DOI: 10.1007/BF01064262.

[Singh Bhatti et al. 2010]Singh Bhatti, Rajbir, Pradeep Kumar, and Dinesh Kumar (2010). "Analytical modeling of third party service provider selection in lead logistics provider environments". In: *Journal of Modelling in Management* 5.3, pp. 275–286. ISSN: 1746-5664. DOI: 10.1108/17465661011092641.

[Singh and Acharya 2013]Singh, Rohit Kr. and P. Acharya (2013). "Supply Chain Flexibility: A Frame Work of Research Dimensions". In: *Global Journal of Flexible Systems Management* 14.3, pp. 157–166. ISSN: 0972-2696. DOI: 10.1007/s40171-013-0039-4.

[Smith 1988]Smith, Gerald F. (1988). "Towards a heuristic theory of problem structuring". In: *Management science* 34.12, pp. 1489–1506.

[Smith 1992]— (1992). "Towards a theory of managerial problem solving". In: *Decision Support Systems* 8.1, pp. 29–40. ISSN: 01679236. DOI: 10.1016/0167-9236(92)90035-N.

[Stadtler et al. 2012]Stadtler, Hartmut, Bernhard Fleischmann, Martin Grunow, Herbert Meyr, and Christopher Sürie (2012). *Advanced Planning in Supply Chains.* Berlin, Heidelberg: Springer Berlin Heidelberg. ISBN: 978-3-642-24214-4. DOI: 10.1007/978-3-642-24215-1.

[Stefansson 2006]Stefansson, Gunnar (2006). "Collaborative logistics management and the role of third–party service providers". In: *International Journal of Physical Distribution & Logistics Management* 36.2, pp. 76–92. ISSN: 0960-0035. DOI: 10.1108/09600030610656413.

[Steghuis 2006]Steghuis, Claudia (2006). *Service granularity in SOA-projects: A trade-off analysis.* URL: http://essay.utwente.nl/57339/.

[Stevenson and Spring 2007]Stevenson, Mark and Martin Spring (2007). "Flexibility from a supply chain perspective: Definition and review". In: *International*

Journal of Operations & Production Management 27.7, pp. 685–713. DOI: 10.1108/01443570710756956.

[Straube et al. 2008]Straube, Frank, Shihua Ma, and Michael Bohn, eds. (2008). *Internationalisation of Logistics Systems: How Chinese and German companies enter foreign markets.* Berlin, Heidelberg: Springer Berlin Heidelberg. ISBN: 978-3-540-76982-8. DOI: 10.1007/978-3-540-76984-2.

[Suárez-Figueroa et al. 2012]Suárez-Figueroa, Mari Carmen, Asunción Gómez-Pérez, and Mariano Fernández-López (2012). "The NeOn Methodology for Ontology Engineering". In: *Ontology Engineering in a Networked World*. Ed. by Mari Carmen Suárez-Figueroa, Asunción Gómez-Pérez, Enrico Motta, and Aldo Gangemi. Berlin, Heidelberg: Springer Berlin Heidelberg, pp. 9–34. ISBN: 978-3-642-24793-4. DOI: 10.1007/978-3-642-24794-1{_}2.

[Subramanian et al. 2016]Subramanian, Nachiappan, Angappa Gunasekaran, Thanos Papadopoulos, and Pie Nie (2016). "4th party logistics service providers and industrial cluster competitiveness". In: *Industrial Management & Data Systems* 116.7, pp. 1303–1330. ISSN: 0263-5577. DOI: 10.1108/IMDS-06-2015-0248.

[Sutton and Staw 1995]Sutton, Robert I. and Barry M. Staw (1995). "What theory is not". In: *Administrative science quarterly*, pp. 371–384.

[Tourish and Willmott 2015]Tourish, Dennis and Hugh Willmott (2015). "In Defiance of Folly: Journal rankings, mindless measures and the ABS Guide". In: *Critical Perspectives on Accounting* 26, pp. 37–46. ISSN: 10452354. DOI: 10.1016/j.cpa.2014.02.004.

[Vaquero et al. 2008]Vaquero, Luis M., Luis Rodero-Merino, Juan Caceres, and Maik Lindner (2008). "A break in the clouds". In: *ACM SIGCOMM Computer Communication Review* 39.1, p. 50. ISSN: 01464833. DOI: 10.1145/1496091.1496100.

[Varian 2004]Varian, Hal R. (2004). *Review of Mokyr's "Gifts of Athena".*

[Venable et al. 2014]Venable, John, Jan Pries-Heje, and Richard Baskerville (2014). "FEDS: A Framework for Evaluation in Design Science Research". In: *European Journal of Information Systems*. ISSN: 0960-085X. DOI: 10.1057/ejis.2014.36.

[Vezzoli et al. 2014]Vezzoli, Carlo, Cindy Kohtala, Amrit Srinivasan, Jan Carel Diehl, Sompit Moi Fusakul, Xin Liu, and Deepta Sateesh (2014). *Product-service system design for sustainability.* Sheffield: Greenleaf Publishing. ISBN: 978-1-909493-69-8.

[Vom Brocke, Simons, Niehaves, et al. 2009]Vom Brocke, Jan, Alexander Simons, Bjoern Niehaves, Kai Riemer, Ralf Plattfaut, Anne Cleven, et al. (2009). "Reconstructing the giant: On the importance of rigour in documenting the literature search process". In: *European Conference on Information Systems (ECIS)*. Vol. 9, pp. 2206–2217.

[Vom Brocke, Simons, Riemer, et al. 2015]Vom Brocke, Jan, Alexander Simons, Kai Riemer, Bjoern Niehaves, Ralf Plattfaut, and Anne Cleven (2015). "Standing on the Shoulders of Giants: Challenges and Recommendations of Literature Search in Information Systems Research". In: *Communications of the Association for Information Systems* 37.9, pp. 205–224.

[Walstrom and Hardgrave 2001]Walstrom, Kent A. and Bill C. Hardgrave (2001). "Forums for information systems scholars: III". In: *Information & Management* 39.2, pp. 117–124. ISSN: 03787206.

[Webster and Watson 2002]Webster, Jane and Richard T. Watson (2002). "Analyzing the Past to Prepare for the Future: Writing a Literature Review". In: *MIS Quarterly* Vol. 26.No. 2, pp. 13–23.

[Wickelgren 1974]Wickelgren, Wayne A. (1974). *How to solve problems; Elements of a theory of problems and problem solving*. A series of books in psychology. San Francisco: W.H. Freeman. ISBN: 9780716708452.

[Wieland et al. 2016]Wieland, Andreas, Robert B. Handfield, and Christian F. Durach (2016). "Mapping the Landscape of Future Research Themes in Supply Chain Management". In: *Journal of Business Logistics* 37.3, pp. 205–212. ISSN: 07353766. DOI: 10.1111/jbl.12131.

[Wilde and Hess 2007]Wilde, Thomas and Thomas Hess (2007). "Forschungsmethoden der Wirtschaftsinformatik". In: *WIRTSCHAFTSINFORMATIK* 49.4, pp. 280–287. ISSN: 0937-6429. DOI: 10.1007/s11576-007-0064-z.

[Wilding and Juriado 2004]Wilding, Richard and Rein Juriado (2004). "Customer perceptions on logistics outsourcing in the European consumer goods industry". In: *International Journal of Physical Distribution & Logistics Management* 34.8, pp. 628–644. ISSN: 0960-0035. DOI: 10.1108/09600030410557767.

[Willcocks et al. 2008]Willcocks, Leslie, Edgar A. Whitley, and Chrisanthi Avgerou (2008). "The ranking of top IS journals: A perspective from the London School of Economics". In: *European Journal of Information Systems* 17.2, pp. 163–168. ISSN: 0960-085X. DOI: 10.1057/ejis.2008.9.

[Williams 2007]Williams, Andrew (2007). "Product service systems in the automobile industry: Contribution to system innovation?" In: *Journal of Cleaner Production* 15.11-12, pp. 1093–1103. ISSN: 09596526. DOI: 10.1016/j.jclepro.2006.05.034.

[Willmott 2011]Willmott, Hugh (2011). "Journal list fetishism and the perversion of scholarship: Reactivity and the ABS list". In: *Organization* 18.4, pp. 429–442. ISSN: 1350-5084. DOI: 10.1177/1350508411403532.

[Win 2008]Win, Alan (2008). "The value a 4PL provider can contribute to an organisation". In: *International Journal of Physical Distribution & Logistics Management* 38.9, pp. 674–684. ISSN: 0960-0035. DOI: 10.1108/09600030810925962.

[Wu et al. 2013]Wu, Dazhong, Matthew John Greer, David W. Rosen, and Dirk Schaefer (2013). "Cloud manufacturing: Strategic vision and state-of-the-art". In: *Journal of Manufacturing Systems* 32.4, pp. 564–579. ISSN: 02786125. DOI: 10.1016/j.jmsy.2013.04.008.

[Xu 2012]Xu, Xun (2012). "From cloud computing to cloud manufacturing". In: *Robotics and Computer-Integrated Manufacturing* 28.1, pp. 75–86. ISSN: 07365845. DOI: 10.1016/j.rcim.2011.07.002.

[Ye et al. 2008]Ye, Yan, Dong Yang, Zhibin Jiang, and Lixin Tong (2008). "An ontology-based architecture for implementing semantic integration of supply chain management". In: *International Journal of Computer Integrated Manufacturing* 21.1, pp. 1–18. URL: http://www.tandfonline.com/doi/citedby/10.1080/09511920601182225.

[Zacharia et al. 2011]Zacharia, Zach G., Nada R. Sanders, and Nancy W. Nix (2011). "The Emerging Role of the Third-Party Logistics Provider (3PL) as an Orchestrator". In: *Journal of Business Logistics* 32.1, pp. 40–54. ISSN: 07353766. DOI: 10.1111/j.2158-1592.2011.01004.x.

[L. Zhang et al. 2012]Zhang, Lin et al. (2012). "Cloud manufacturing: A new manufacturing paradigm". In: *Enterprise Information Systems* 8.2, pp. 167–187. ISSN: 1751-7575. DOI: 10.1080/17517575.2012.683812.

[Q. Zhang et al. 2010]Zhang, Qi, Lu Cheng, and Raouf Boutaba (2010). "Cloud computing: State-of-the-art and research challenges". In: *Journal of Internet Services and Applications* 1.1, pp. 7–18. ISSN: 1867-4828. DOI: 10.1007/s13174-010-0007-6.

Curriculum Vitae

Personal Details

Name:	Michael Glöckner
Address:	Petersstraße 16, 04109 Leipzig, Germany
Birth Data:	02.12.1986, in Wurzen, Germany
Contact:	michael.gloeckner.le@gmail.com

Education and Academic History

2012 - 2018	**Research Assistant & PhD Student in Information Systems** at Chair of Logistics Information Systems, *Leipzig University*, Germany - research interest: Cloud Logistics, Service Science - project *Logistik Service Engineering & Management* (BMBF LSEM) - project *Smarte Last Mile Logistik* (BMWi SMile) - supervisor for Bachelor and Master Theses
2016	**Visiting Researcher** at Chair of Computer Science in Logistics, *Kühne Logistics University*, Hamburg, Germany
2005 - 2012	**Diploma Student in Transport Engineering** at *Dresden University of Technology*, Germany - degree: Diplom-Ingenieur für Verkehrswesen - majoring in Transport Systems Technology and Logistics
2010 - 2011	**Erasmus Scholarship Student** at *Universidad de Sevilla*, Spain
2008 - 2009	**Student Assistant & Tutor** in Transport Logistics at *Dresden University of Technology*, Germany

Practical Experience

2012	**Diploma Thesis & Internship** Production Logistics Research at *IPH - Institut für Integrierte Produktion Hannover gGmbH*, Germany
2011	**Internship** Corporate Development and Internal Consulting at *Deutsche Bahn Mobility Logistics AG*, Frankfurt (Main), Germany
2011	**Internship** Business Administration Research at *IPRI - International Performance Research Institute gGmbH*, Stuttgart, Germany
2009 - 2010	**Student Research Thesis & Internship** Centralized Procurement Logistics and Material Control at *BMW AG*, Plant Leipzig, Germany

Leipzig, 22. Januar 2019 Michael Glöckner

Selbständigkeitserklärung

Hiermit versichere ich, dass

1. die vorgelegte Dissertation ohne unzulässige Hilfe, insbesondere ohne die Inanspruchnahme eines Promotionsberaters, und ohne Benutzung anderer als der angegebenen Hilfsmittel angefertigt wurde und dass die aus fremden Quellen direkt oder indirekt übernommenen Gedanken in der Arbeit als solche kenntlich gemacht worden sind und

2. die vorgelegte Dissertation weder im Inland noch im Ausland in gleicher oder in ähnlicher Form einer anderen Prüfungsbehörde zum Zwecke einer Promotion oder eines anderen Prüfungsverfahrens vorgelegt und insgesamt noch nicht veröffentlicht wurde.

Leipzig, 22. Januar 2019 Michael Glöckner